Smart Buildings with Cisco Catalyst 9000 Switches
Certified Green Testing

October 2021

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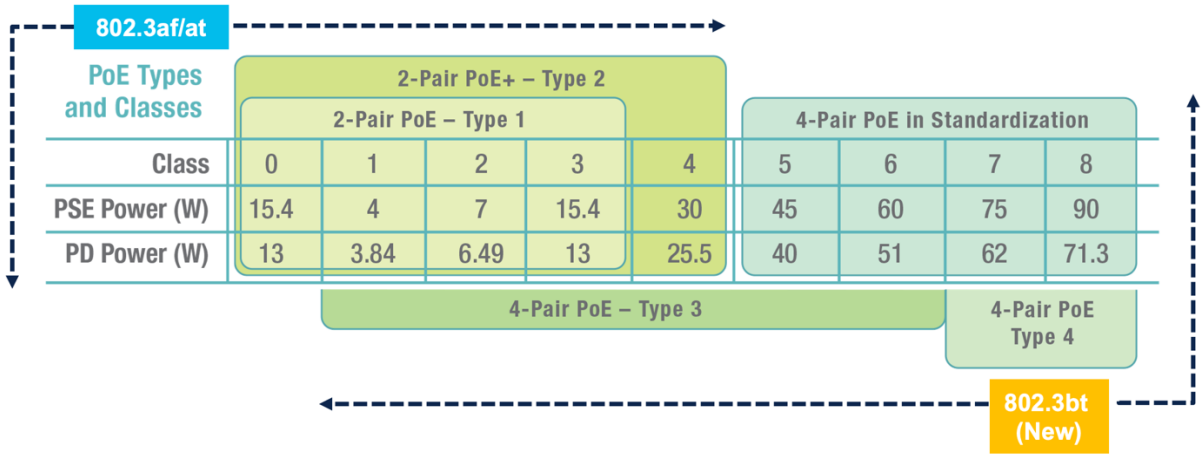
Contents

1.0 Executive Summary

We continue to see more and more endpoints onboarding the network using Power Over Ethernet (PoE). This standardized technology with evolving applications provides cost savings by powering endpoints at low voltage. The networking infrastructure can be leveraged to power the endpoints as well as provide network connectivity at the same time.

With the continued use of PoE powered lights, motorized shades, HVACs, USB-C dongles, large displays, high resolution cameras and other appliances using more than 60 watts (W), 90W is becoming more prevalent as the National Electric Code removes the 60W limitation for PoE. The increased use of USB-C dongles brings opportunity for providing power and network connectivity simultaneously to laptops and other devices that can be powered by USB-C ports. Moreover, 90W ports makes daisy chaining of lights possible, helping with energy savings where a single 90W port can be used to power multiple lights.

The latest standard for PoE, IEEE 802.3bt, introduces two new types, Type 3 and Type 4 for up to 90W of power, driving the new Internet of Things (IoT) use cases seen today in the rapidly evolving network landscape.



As a PoE industry leader, Cisco engaged Miercom to test new capabilities and features that its Catalyst 9000 Series switches offer for Smart Building Deployments. The Cisco Catalyst 9300 and Catalyst 9400 series switches both support Cisco Universal Power over Ethernet Plus (UPOE+) and are IEEE 802.3bt Type 3 and Type 4 compliant.

Cisco knows how important 90W PoE is, as it is rapidly becoming a utility. By switching to Catalyst 9000 Series UPOE/UPOE+ models, customers can benefit from cost savings and seamlessly converge IT and OT infrastructure. Direct current (DC) powering technology eliminates the need to invest in alternating current (AC) cabling conduits, and 90W PoE provides the ability to safely daisy chain multiple devices to a single port.

Cisco Catalyst 9000 Series switches with standards based 802.3bt capabilities provide densest PoE options to enable the next generation flexible workspace. Catalyst 9300 and 9400 UPOE/UPOE+ ports could scale up to 256 90W ports on a 9300 in a stacked environment and up to 260 90W ports on the 9400 Modular chassis, giving customers flexible options to choose for the PoE deployments. Its PoE power sources are reliable; PoE assurance is guaranteed by Cisco DNA Center, which provides a complete view of connected end points, PoE capabilities and troubleshooting tools from a single dashboard. Cisco AI End point Analytics auto profiles endpoints seamlessly as they on-board the network. ISE can use these end point profiles to provide customized policies to secure the end points. Lastly, Cisco DNA Spaces, a SaaS-based cloud platform, delivers new business outcomes by leveraging the Application Hosting framework of the Catalyst 9000 Series switches.

By looking at multiple common 90W use cases, we proved Cisco Smart Building with Catalyst 9000 Series switches provide feature rich PoE capabilities that are worth investing in. Below are our highlighted findings.

Key Findings:

- **Superior Portfolio of UPOE and UPOE+ Capabilities:** With Cisco Smart Building, the Cisco Catalyst 9000 series switches successfully provide features such as UPOE+, Perpetual PoE, Fast PoE, Intelligent Load Shedding, Port priority.
- **Fast Power Restoration:** The Fast PoE feature helps restore power to end points within 23 seconds upon a power failure.
- **Highest Power Resiliency:** Catalyst 9000 switches provide seamless hardware redundancy with capabilities like 1+N, N+N redundant power supplies, mixed AC and DC sources, and StackPower (9300).
- **Seamless Integration with third-party endpoints:** The Cisco Catalyst 9000 Series switches work with a large ecosystem of PoE powered end points and their accompanying applications. Catalyst 9300 and 9400 Series switches are 802.3bt complaint up to 90W and seamlessly interoperate with IEEE 802.3bt compliant devices. The switches also interoperate with legacy PoE devices, covering all existing and new PoE devices as it supports a wide powering spectrum from 15W to 90W.
- **Simplified, Centralized Management via Cisco DNA Center:** Cisco DNA Center acts as a single pane-of-glass to onboard, provision and perform image upgrade at scale on the network devices. Assurance capabilities of DNA Center provide Network, Client and Application Assurance. PoE Assurance provides in-depth PoE network analysis and overview through a user-friendly interface to help customers plan, monitor, and troubleshoot the network.
- **Insightful Visual Aids for Quick Analysis:** Cisco DNA Center PoE Assurance shows powered endpoint device details, trends, event timelines, PoE categorization and classification. The PoE Insights highlights Perpetual PoE, Fast PoE, IEEE compliant and UPOE+ enabled devices.

- **AI Endpoint Analytics:** AI Endpoint Analytics provides users with additional benefits of auto profiling the endpoints by leveraging the Deep packet inspection capabilities of Catalyst 9000 switches. AI Endpoint Analytics combined with ISE provides seamless segmentation to secure the network.
- **Application Hosting:** Catalyst 9000 series switches application hosting is a key innovation and provides Edge computing at no additional cost to host third-party docker containers using Cisco Application Hosting Framework.
- **SaaS-based Cloud Integration to Deliver New Outcomes:** Cisco DNA Spaces, a SaaS-based platform, delivers new outcomes like Sustainable Buildings, Employee Health & Safety, Productivity improvements, and Building Analytics.

Based on our findings, we found the Cisco Smart Building solution to offer industry leading PoE capabilities. It impressed with its superior connectivity, assurance, and extension of environmentally friendly network power across multiple real-world scenarios. We proudly award the Cisco Smart Building solution, the ***Miercom Certified Green*** accreditation in recognition of its positive contribution to the environment.

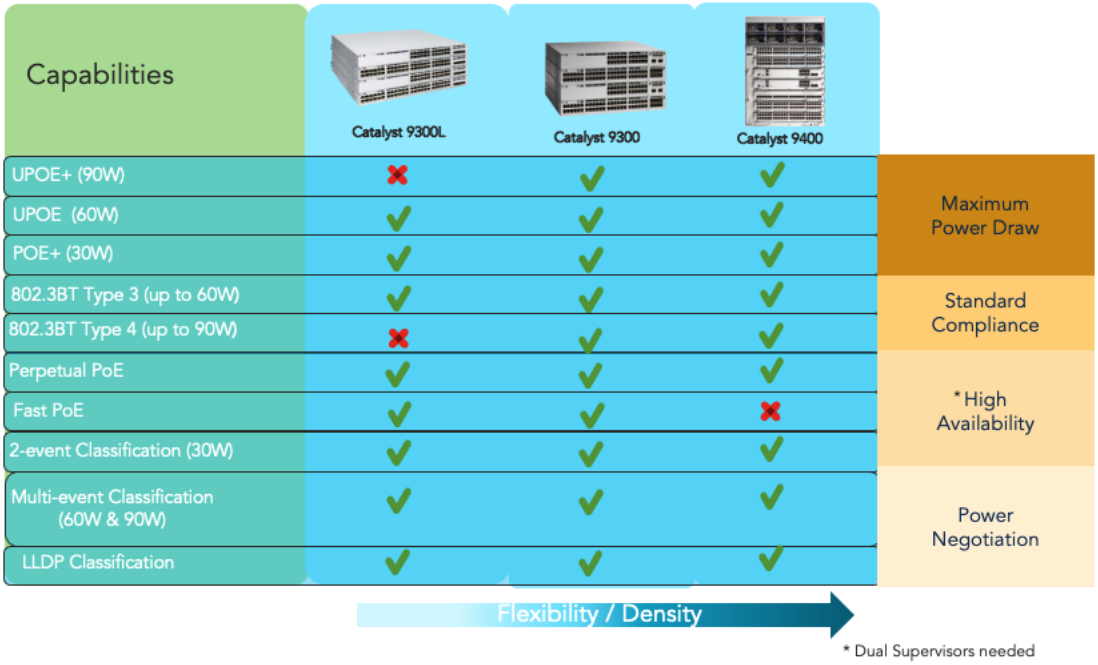
Robert Smithers
CEO, Miercom

2.0 Introduction

PoE is a widely used technology that provides electrical power to endpoints over twisted pair Ethernet cabling to power the endpoints in addition to the data that the cable usually caries. PoE powers numerous endpoints and removes the need for in-depth wiring or conversion. Additionally, it decreases the costs of deployments and ensures safety for both the endpoint and user when using standardized technologies.

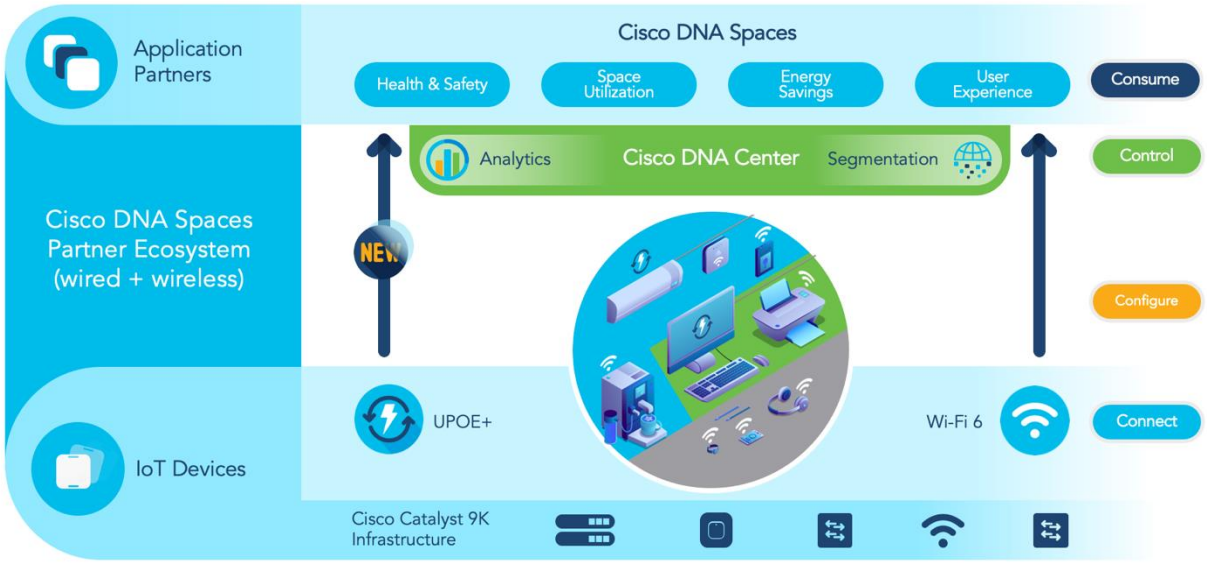
In 2011, Cisco introduced UPOE (up to 60W) to leverage all four-twisted pairs on Category 5e and above cables. In 2018, the IEEE 802.3bt standard increased the maximum power to 90W which allows for Smart Building enablement where it is possible to power even more IoT devices.

The Smart Building features are supported on the Cisco Catalyst 9000 series, specifically the Cisco Catalyst 9300L, 9300, and 9400. UPOE+ is not supported on the 9300L and Fast PoE is not supported for the Catalyst 9400.



The above displays the features supported by the Catalyst 9300L, 9300, and 9400. Note that UPOE+ is not supported on the 9300L and Fast PoE is not supported for the Catalyst 9400.

3.0 Cisco Smart Building Architecture



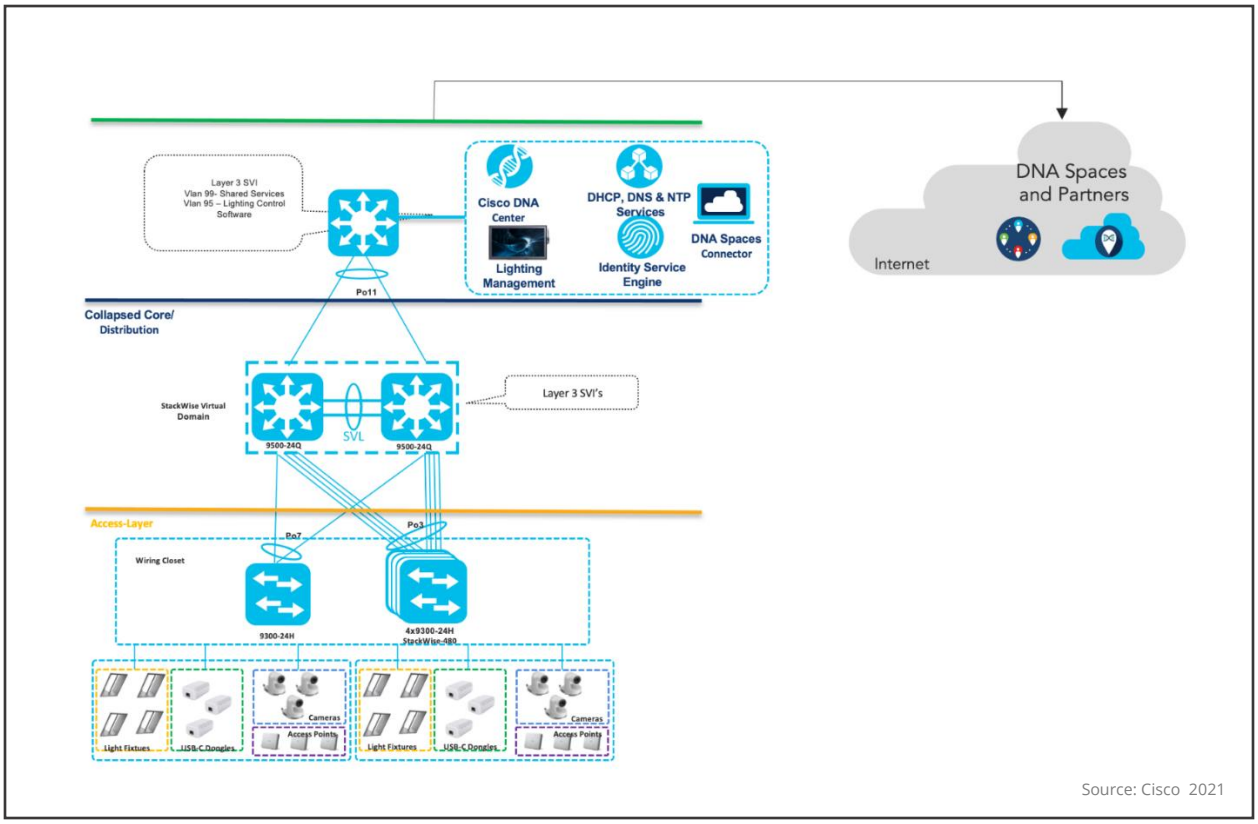
Cisco Smart Building Architecture consists of multiple features layered together, with Catalyst 9000 switching platforms and wireless access points acting as the backbone for the solution at the Access Layer. Cisco UPOE/UPOE+ and mGig capabilities of Catalyst 9000 switching platforms lay the foundation for this architecture. The Cisco DNA Center, a network controller and management dashboard, provides a single dashboard for every fundamental management task and provide Assurance at the same time. Cisco ISE enables a dynamic and automated approach to policy enforcement for simplified delivery of highly secure network access control. Cisco DNA Spaces, a SaaS-based platform, assists with location-based analytics to deliver new outcomes to the customer.

In this report, we analyzed the solution at each layer to determine the functionality, capability, and reliability of the solution.

4.0 How We Did It

By observing the Cisco Smart Building solution in many real-world use case scenarios, we validated features and performance for the Miercom Certified Green accreditation.

Test Bed Overview



PoE device control was verified on a twisted pair Ethernet cable, up to 100 meters.

A wide variety of PoE endpoints were connected at the Access Layer to the Catalyst 9300H models (9300-24H) which are 90W capable. Endpoint types included PoE lighting Fixtures from multiple third-party vendors, PoE sensors, PoE powered USB-C dongles, Cisco access points, Cisco and third-party PoE powered cameras, PoE powered Cisco IP Phones, Cisco UPOE passthrough switches, and Meraki cameras.

A pair of Cisco Catalyst 9500 switches (9500-24Q), configured in Stackwise Virtual mode (SV), acted as a collapsed core for this topology.

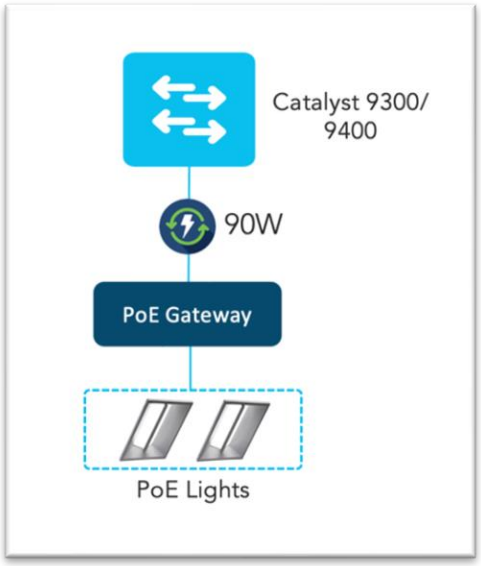
Services such as DHCP server, DNS Server, Cisco DNA Center, and Cisco ISE were connected at the Data Center Layer to provide centralized services to the endpoints connected at the Access Layer.

Products Tested

Hardware/Software	Version
Igor Lights	
Igor Network Node	Rev 7: NP70-99-8-F Rev 8: NP60-99-T-F
Igor Management Interface	
Igor Gateway Software	Ver. 5.6.1
MazeMap	Ver. 5.2.23
Molex PoE Node	CoreSync PoE Gateway 2.0
Molex Management Software	CoreSync Manager V1 4.0.57
PoE Endpoints	Lighting endpoints, occupancy sensors, 4K cameras, IP phones, PoE passthrough switches
Cisco Catalyst 9300H/9500-24Q Switches	17.3.1
Cisco DNA Center	2.2.2.0
Cisco ISE	Release 2.7

5.0 PoE Features

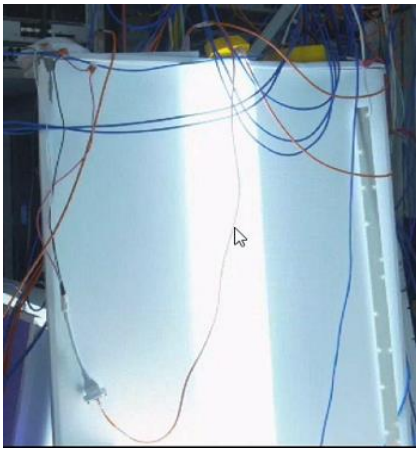
5.1 802.3 BT Negotiation



We observed how UPOE+ lights negotiate the appropriate power both at hardware, without LLDP (Link Layer Discovery Protocol), and software with LLDP enabled.

Test setup:

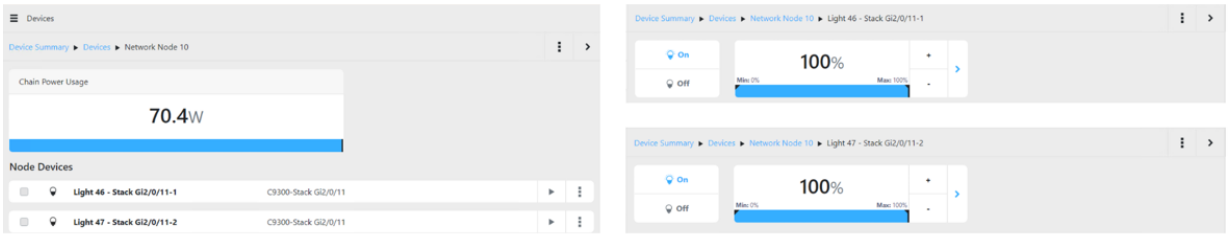
With LLDP disabled on the switch, 802.3bt, 90W capable PoE Gateways were connected to the Catalyst switches. Two daisy chained light fixtures were connected to the PoE Gateway – the Powered Device (PD). We saw Power successfully negotiated up to 90W (Class 8) between the switch – the Power Sourcing Equipment (PSE) and the PoE Gateway (PD). 802.3bt power negotiation happened successfully between the PoE Gateway and the Catalyst switch and lights were turned on successfully after the negotiation.



We observed successful 802.3bt power negotiation between the PoE Gateway (PD) and the Catalyst switch (PSE) over Ethernet. Lights turned on successfully after the negotiation.

```
C9300-Stack#sh power inline gigabitEthernet 2/0/11 detail
 Interface: Gi2/0/11
 Inline Power Mode: auto
 Operational status (Alt-A,B): on,on
 Device Detected: yes
 Device Type: Ieee PD
 Connection Check: SS
 IEEE Class (Alt-A,B): 8
 Physical Assigned Class (Alt-A,B): 8
 Discovery mechanism used/configured: Ieee and Cisco
 Police: off

 Power Allocated
 Admin Value: 90.0
 Power drawn from the source: 90.0
 Power available to the device: 90.0
 Allocated Power (Alt-A,B): 90.0

 Actual consumption
 Measured at the port(watts) (Alt-A,B): 72.0
 Maximum Power drawn by the device since powered on: 72.0

 Absent Counter: 0
 Over Current Counter: 0
 Short Current Counter: 0
 Invalid Signature Counter: 0
 Power Denied Counter: 0

 Power Negotiation Used: None
 LLDP Power Negotiation       --Sent to PD--      --Rcvd from PD--
 Power Type:                  -                    -
 Power Source:                -                    -
 Power Priority:              -                    -
 Requested Power(W):          -                    -
 Allocated Power(W):          -                    -

Four-Pair PoE Supported: Yes
Spare Pair Power Enabled: Yes
Four-Pair PD Architecture: Shared
C9300-Stack#
```

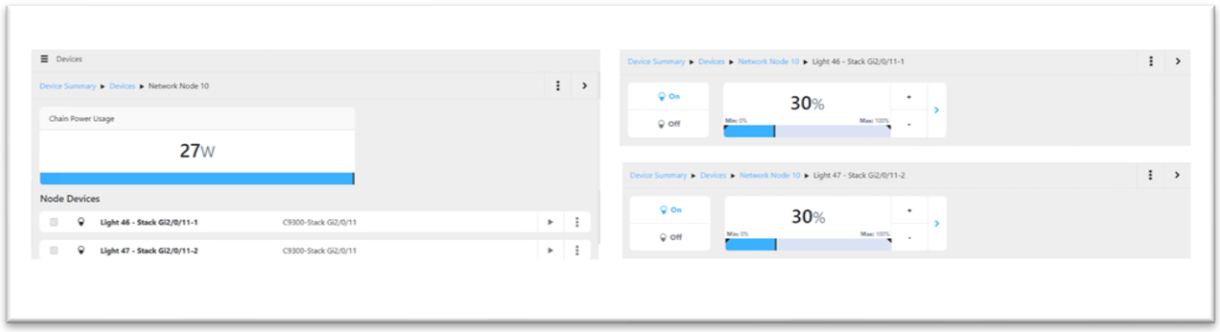
Successful 802.3bt negotiation as seen from the switch. We observed that PoE negotiated to Class 8 and been allocated 90W by the switch (PSE).



Above shows both the light fixtures are at 100% brightness and the power at the PD.

```
C9300-Stack#sh power inline gigabitEthernet 2/0/11 detail
 Interface: Gi2/0/11
 Inline Power Mode: auto
 Operational status (Alt-A,B): on,on
 Device Detected: yes
 Device Type: Ieee PD
 Connection Check: SS
 IEEE Class (Alt-A,B): 8
 Physical Assigned Class (Alt-A,B): 8
 Discovery mechanism used/configured: Ieee and Cisco
 Police: off

 Power Allocated
 Admin Value: 90.0
 Power drawn from the source: 90.0
 Power available to the device: 90.0
 Allocated Power (Alt-A,B): 90.0

 Actual consumption
 Measured at the port(watts) (Alt-A,B): 27.3
 Maximum Power drawn by the device since powered on: 72.0

 Absent Counter: 0
 Over Current Counter: 0
 Short Current Counter: 0
 Invalid Signature Counter: 0
 Power Denied Counter: 0

 Power Negotiation Used: None
 LLDP Power Negotiation       --Sent to PD--      --Rcvd from PD--
 Power Type:                  -                    -
 Power Source:                -                    -
 Power Priority:              -                    -
 Requested Power(W):          -                    -
 Allocated Power(W):          -                    -

Four-Pair PoE Supported: Yes
Spare Pair Power Enabled: Yes
Four-Pair PD Architecture: Shared
C9300-Stack#
```

We observed the brightness of the light fixtures being adjusted from the lighting controller software and were able to see the brightness change successfully on the lights. This change was reflected on the switch port, where the actual consumption measured at the port transitioned to 27.3W with a change in brightness of the lights.



Above shows both the light fixtures are at 30% brightness and the power at the PD.

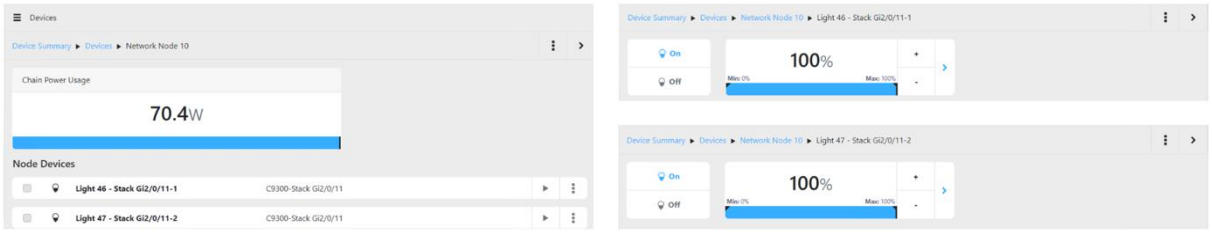
5.2 802.3 BT Negotiation and LLDP

We observed how UPOE+ lights negotiate power after enabling LLDP (Link Layer Discovery Protocol). LLDP is a vendor neutral Layer 2 protocol used by network devices to advertise their identity, capabilities and neighborship. It provides the capability to exchange TLV's (Type-Length-Value) with a neighboring device. During testing, we viewed the ability of the switch to negotiate power at hardware and display additional information regarding the end point like PD class, Power Type, Product type, vendor information via LLDP protocol.

Similar activity as stated in 5.1 was carried out by enabling LLDP on the switch.

As seen from the output, PoE was negotiated as Type 4 PSE and Class 8, which is 90W. LLDP compliments the hardware negotiation by providing additional details like PD class, Power Type, Product type, vendor specific information along with the capability to negotiate at custom power values should the PD require lower power than initially negotiated.

```
C9300-Stack#sh power inline gigabitEthernet 2/0/11 detail
 Interface: Gi2/0/11
 Inline Power Mode: auto
 Operational status (Alt-A,B): on,on
 Device Detected: yes
 Device Type: Ieee PD
 Connection Check: SS
 IEEE Class (Alt-A,B): 8
 Physical Assigned Class (Alt-A,B): 8
 Discovery mechanism used/configured: Ieee and Cisco
 Police: off

 Power Allocated
 Admin Value: 90.0
 Power drawn from the source: 90.0
 Power available to the device: 90.0
 Allocated Power (Alt-A,B): 90.0

 Actual consumption
 Measured at the port(watts) (Alt-A,B): 72.0
 Maximum Power drawn by the device since powered on: 72.0

 Absent Counter: 0
 Over Current Counter: 0
 Short Current Counter: 0
 Invalid Signature Counter: 0
 Power Denied Counter: 0

 Power Negotiation Used: IEEE 802.3bt LLDP
 LLDP Power Negotiation       --Sent to PD--      --Rcvd from PD--
 Power Type:                  Type 2 PSE          Type 2 PD
 Power Source:                Primary             PSE
 Power Priority:              low                 critical
 PD 4PID:                     0                   0
 Requested Power(W):          71.3                71.3
 Allocated Power(W):          71.3                71.3
 Requested Power ModeA(W):    0.0                 0.0
 Allocated Power ModeA(W):    0.0                 0.0
 Requested Power ModeB(W):    0.0                 0.0
 Allocated Power ModeB(W):    0.0                 0.0
 PSE Powering Status:         4 pair SS PD        Ignore
 PD Powering Status:          Ignore              SS PD
 PSE Power Pair ext:          Both Alternatives   Ignore
 DS Class Mode A ext:         SS PD               SS PD
 DS Class Mode B ext:         SS PD               SS PD
 SS Class ext:                Class 8             Class 8
 PSE Type ext:                Type 4 PSE          Ignore
 PSE Max Avail Power:         71.3                0.0
 PSE Auto Class Supp:         No                  No
 PD Auto Class Req:           No                  No
 PD Power Down Req:           No                  No
 PD Power Down Time(sec):     0                   0

Four-Pair PoE Supported: Yes
Spare Pair Power Enabled: Yes
Four-Pair PD Architecture: Shared
```



Light fixtures are at 100% brightness, and the power at the PD has LLDP enabled on the switch.

```
C9300-Stack#sh lldp neighbors g2/0/11 detail
------------------------------------------------
Local Intf: Gi2/0/11
Chassis id: 500b.9100.947c
Port id: 1
Port Description: 1
System Name: Igor Network Node

System Description:
Igor Node X.X.X

Time remaining: 157 seconds
System Capabilities: S
Enabled Capabilities: S
Management Addresses:
    IP: 172.16.10.24
    Other: 50 0B FF 00 FF 7C 00
Auto Negotiation - not supported
Physical media capabilities - not advertised
Media Attachment Unit type - not advertised
Vlan ID: - not advertised
PoE+ Power-via-MDI TLV:
 Power Pair: Signal
 Power Class: Class 4
 Power Device Type: Type 2 PD
 Power Source: PSE
 Power Priority: critical
 Power Requested: 71300 mW
 Power Allocated: 71300 mW

MED Information:

    MED Codes:
          (NP) Network Policy, (LI) Location Identification
          (PS) Power Source Entity, (PD) Power Device
          (IN) Inventory

    Inventory information - not advertised
    Capabilities: PD
    Device type: Network connectivity
    Network Policies - not advertised
    Power requirements - not advertised
    Location - not advertised


Total entries displayed: 1

C9300-Stack#
```

Additional information regarding the endpoint is displayed after turning on the LLDP protocol.

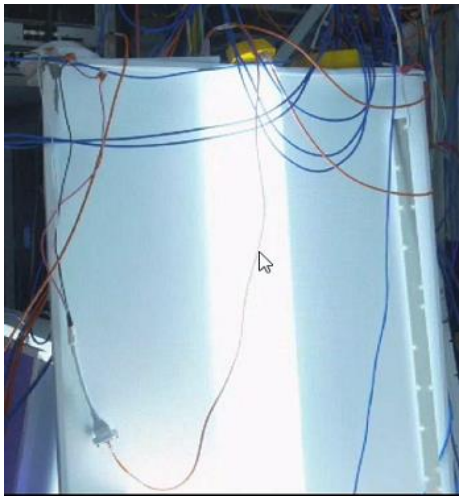
```
C9300-Stack#sh device-sensor cache interface g2/0/11
Device: 500b.9100.947c on port GigabitEthernet2/0/11
-------------------------------------------------------------------------------
Proto Type:Name                       Len Value                     Text
DHCP    52:option-overload              3 34 01 01                  4..
DHCP    54:server-identifier            6 36 04 AC 10 63 35         6.,.c5
DHCP     6:domain-name-servers         10 06 08 AC 10 63 35 AC 1A CA  ..,.c5,.J
                                        35                          5
DHCP     3:routers                      6 03 04 AC 10 0A 01         ..,...
DHCP     1:subnet-mask                  6 01 04 FF FF FF 00         ......
DHCP    50:requested-address            6 32 04 AC 10 0A 18         2.,...
DHCP     0:<unknown>                    2 00 00                     ..
DHCP   255:end                          5 FF 03 32 04 AC            ..2.,
DHCP    55:parameter-request-list       7 37 05 01 03 06 0F E5      7.....e
DHCP    51:lease-time                   6 33 04 00 0A 8C 00         3...^L.
DHCP    53:message-type                 3 35 01 03                  5..
LLDP     0:end-of-lldpdu                2 00 00                     ..
LLDP   127:organizationally-specific   68 FE 42 00 00 5E 01 68 74 74  .B..^.htt
                                          70 73 3A 2F 2F 6D 75 64 2E  ps://mud.
                                          69 67 6F 72 2D 74 65 63 68  igor-tech
                                          2E 63 6F 6D 2F 6D 75 64 2F  .com/mud/
                                          69 67 6F 72 2D 6E 65 74 77  igor-netw
                                          6F 72 6B 6E 6F 64 65 2D 6D  orknode-m
                                          75 64 66 69 6C 65 2D 76 31  udfile-v1
                                          2E 6A 73 6F 6E              .json
LLDP     8:management-address          16 10 0E 07 06 50 0B 91 00 94  ....P.^Q.^T
                                          7C 02 00 00 00 01 00        |......
LLDP     7:system-capabilities          6 0E 04 00 80 00 80         ...^@.^@
LLDP     6:system-description          17 0C 0F 49 67 6F 72 20 4E 6F  ..Igor No
                                          64 65 20 58 2E 58 2E 58     de X.X.X
LLDP     5:system-name                 19 0A 11 49 67 6F 72 20 4E 65  ..Igor Ne
                                          74 77 6F 72 6B 20 4E 6F 64  twork Nod
                                          65                          e
LLDP     4:port-description             3 08 01 31                  ..1
LLDP     3:time-to-live                 4 06 02 00 B4               ...4
LLDP     2:port-id                      4 04 02 07 31               ...1
LLDP     1:chassis-id                   9 02 07 04 50 0B 91 00 94 7C  ...P.^Q.^T|
```

The switch learns the TLV's as advertised by the vendor. Some of these TLV's can be used for other features/functionalities. In above snapshot, TLV 127 is used for Manufacturer Usage Description (MUD) to create an Authorization policy in ISE and push a dynamic ACL or SGT to the port.

5.3 Perpetual PoE

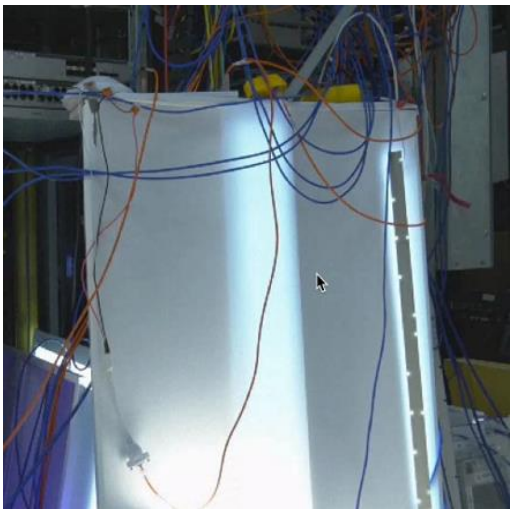
Perpetual PoE (PPoE) is a switch feature that allows clients to continue to receive *Last Negotiated Power* during a switch soft reload. Soft reloads include image upgrades, software crashes, and manual reboots. This feature is supported in both standalone and stacking deployment. This feature is not applicable to power outages, power supply removal, and switch hibernation mode.

During the live demonstration, a switch reload was performed and the behavior of the Igor lights were observed.



Light is shown as on prior to switch reload.

```
C93-Standalone#reload
Reload command is being issued on Active unit, this will reload the whole stack
Proceed with reload? [confirm]

Chassis 1 reloading, reason - Reload command
Apr 22 18:32:41.652: %PMAN-5-EXITACTION: F0/0: pvp: Process manager is exiting: reload fp action requested
Apr 22 18:32:53.260: %PMAN-5-EXITvp: Process manager is exiting: process exit with reload stack code
```



During the reload operation, the light was not switched off demonstrating PPoE feature.

5.4 Fast PoE

Fast PoE remembers the last power drawn (in watts) from specific ports. This power is stored in the NVRAM, allowing the switch to remember and provide power to the endpoint as soon as the device is powered on. After a power failure, a switch in recovery recalls how many watts a particular endpoint on a port negotiated; thus, providing required power to endpoints. Fast PoE begins providing power to devices before IOS forwarding begins.

During testing, we viewed the ability of the Fast PoE to turn on the lights after turning the power supply from "off" to "on" within 23 seconds, which was higher than their datasheet claim.

Note: This feature is not supported on the Catalyst 9400 platform.

5.5 Load Shedding

Load shedding is the process of shutting down devices if a power supply, cable, or system fails. This feature ensures high priority ports are not denied power during a load shedding event upon a power failure. Any remaining power will be distributed to low priority ports. We observed this by first setting the port Gi1/0/10 to a high priority and viewed the changes to the available/remaining watts before and after one of the power supply (PS) failure.

G1/0/10 has been set to high priority port. The switch has two power supplies, a 1,100W PS and a 715W PS (see below).

```
SW   PID                 Serial#     Status           Sys Pwr  PoE Pwr  Watts
--   ------------------  ----------  ---------------  -------  -------  -----
1A   PWR-C1-1100WAC-P    DCC2402D1TQ  OK              Good     Good     1100
1B   PWR-C1-715WAC       DCB1837G2H0  OK              Good     Good     715
```

Total Available PoE is 1,545W. 685.8W has been used to power multiple PoE endpoints.

```
C93-Standalone#sh power inline

Module   Available     Used     Remaining
          (Watts)    (Watts)    (Watts)
------   ---------   --------   ---------
1          1545.0      685.8       859.2
```

Available power was originally 1,545W prior to the power supply cut off.
Remaining power on the device is shown as 859.2W.

The 1,100W PS was unplugged to create a load shedding event. Due to this the device was operating only on a single 715W power supply. In this scenario, available PoE now is only 445W.

```
C93-Standalone#sh power inline

Module   Available     Used     Remaining
          (Watts)     (Watts)    (Watts)
------   ---------   --------   ---------
1           445.0       420.8        24.2
```

Since the available PoE power is only 445W, and the device is operating in power shared strict mode, it must deny power to some low priority ports.

As soon as the 1,100W Power supply was taken down, we saw power denied to low priority ports due to insufficient power.

```
*Jul 29 16:43:34: %ILPOWER-5-DETECT: Interface Gi1/0/13: Power Device detected: IEEE PD
*Jul 29 16:43:34: %ILPOWER-5-ILPOWER_POWER_DENY: Interface Gi1/0/13: inline power denied. Reason: insufficient power
*Jul 29 16:43:34: %ILPOWER-5-DETECT: Interface Gi1/0/14: Power Device detected: IEEE PD
*Jul 29 16:43:34: %ILPOWER-5-ILPOWER_POWER_DENY: Interface Gi1/0/14: inline power denied. Reason: insufficient power
*Jul 29 16:43:36: %ILPOWER-5-DETECT: Interface Gi1/0/15: Power Device detected: IEEE PD
*Jul 29 16:43:36: %ILPOWER-5-DETECT: Interface Gi1/0/17: Power Device detected: IEEE PD
*Jul 29 16:43:36: %ILPOWER-5-ILPOWER_POWER_DENY: Interface Gi1/0/17: inline power denied. Reason: insufficient power
*Jul 29 16:43:36: %ILPOWER-5-DETECT: Interface Gi1/0/15: Power Device detected: IEEE PD
*Jul 29 16:43:36: %ILPOWER-5-ILPOWER_POWER_DENY: Interface Gi1/0/15: inline power denied. Reason: insufficient power
*Jul 29 16:43:37: %SEC_LOGIN-5-LOGIN_SUCCESS: Login Success [user: netadmin] [Source: 172.16.99.97] [localport: 22] at
*Jul 29 16:43:49: %ILPOWER-5-IEEE_DISCONNECT: Interface Gi1/0/13: PD removed
*Jul 29 16:43:49: %ILPOWER-5-IEEE_DISCONNECT: Interface Gi1/0/14: PD removed
*Jul 29 16:43:51: %ILPOWER-5-IEEE_DISCONNECT: Interface Gi1/0/17: PD removed
```

Power denied messages seen in log right after the PS failure.

```
Interface  Admin  Oper        Admin
           State  State       Priority
---------- ------ ----------- ----------

Gi1/0/1    auto   off         low
Gi1/0/2    auto   on          low
Gi1/0/3    auto   off         low
Gi1/0/4    auto   on          low
Gi1/0/5    static on          high
Gi1/0/6    auto   on          low
Gi1/0/7    auto   on          low
Gi1/0/8    auto   on          low
Gi1/0/9    auto   on          low
Gi1/0/10   auto   on          high
Gi1/0/11   auto   off         low
Gi1/0/12   auto   on          low
Gi1/0/13   auto   power-deny  low
Gi1/0/14   auto   power-deny  low
Gi1/0/15   auto   power-deny  low
Gi1/0/16   auto   off         low
Gi1/0/17   auto   power-deny  low
Gi1/0/18   auto   off         low
Gi1/0/19   auto   off         low
 --More--
```

Port status of Gi1/0/10 is "on" as it is set as a high priority.

We saw the port Gi1/0/10 maintain an “on” state during the load shedding event while other low priority ports transitioned to “off” due to insufficient power.

```
          (Watts)     (Watts)    (Watts)
------    ---------   --------   ---------
1           445.0       420.8        24.2
Interface Admin  Oper       Power   Device             Class Max
                            (Watts)
--------- ------ ---------- ------- ------------------ ----- ----
Gi1/0/1   auto   off        0.0     n/a                n/a   90.0
Gi1/0/2   auto   on         15.4    Ieee PD            3     90.0
Gi1/0/3   auto   off        0.0     n/a                n/a   90.0
Gi1/0/4   auto   on         90.0    Ieee PD            8     90.0
Gi1/0/5   static on         30.0    Ieee PD            4     30.0
Gi1/0/6   auto   on         30.0    Ieee PD            4     90.0
Gi1/0/7   auto   on         30.0    WS-C3560CPD-8PT-S  4     90.0
Gi1/0/8   auto   on         90.0    Ieee PD            8     90.0
Gi1/0/9   auto   on         60.0    Ieee PD            4     90.0
Gi1/0/10  auto   on         60.0    Ieee PD            4     90.0
Gi1/0/11  auto   off        0.0     n/a                n/a   90.0
Gi1/0/12  auto   on         15.4    CIVS-IPC-6500PD    0     90.0
Gi1/0/13  auto   power-deny 0.0     n/a                n/a   90.0
Gi1/0/14  auto   power-deny 0.0     n/a                n/a   90.0
Gi1/0/15  auto   power-deny 0.0     n/a                n/a   90.0
Interface Admin  Oper       Power   Device             Class Max
                            (Watts)
--------- ------ ---------- ------- ------------------ ----- ----
Gi1/0/16  auto   off        0.0     n/a                n/a   90.0
Gi1/0/17  auto   power-deny 0.0     n/a                n/a   90.0
Gi1/0/18  auto   off        0.0     n/a                n/a   90.0
Gi1/0/19  auto   off        0.0     n/a                n/a   90.0
```

We observed Gi1/0/10 still “on”, even after the switch power supply was cut. Available watts decreased from 1,545W to 445W.

5.6 Static Power Configurations

Static power configurations allow users to configure a maximum power that an endpoint is allowed to draw on a specific port up to 90W.

During observation, we observed the port Gi1/0/10 connected to a 90W capable endpoint being assigned a static power configuration of 60W and saw the switch trying to provide interface Gi1/0/10 60W power based on the specified configuration.

```
Module   Available     Used     Remaining
          (Watts)    (Watts)    (Watts)
------   ---------   --------   ---------
1          1545.0      625.8       919.2
Interface Admin  Oper       Power   Device              Class Max
                            (Watts)
--------- ------ ---------- ------- ------------------- ----- ----
Gi1/0/1   auto   off        0.0     n/a                 n/a   90.0
Gi1/0/2   auto   on         15.4    Ieee PD             3     90.0
Gi1/0/3   auto   off        0.0     n/a                 n/a   90.0
Gi1/0/4   auto   off        0.0     n/a                 n/a   90.0
Gi1/0/5   static on         30.0    Ieee PD             4     30.0
Gi1/0/6   auto   on         30.0    Ieee PD             4     90.0
Gi1/0/7   auto   on         30.0    WS-C3560CPD-8PT-S   4     90.0
Gi1/0/8   auto   on         90.0    Ieee PD             8     90.0
Gi1/0/9   auto   on         90.0    Ieee PD             8     90.0
Gi1/0/10  auto   off        0.0     n/a                 n/a   90.0
Gi1/0/11  auto   off        0.0     n/a                 n/a   90.0
Gi1/0/12  auto   on         15.4    CIVS-IPC-6500PD     0     90.0
Gi1/0/13  auto   on         90.0    Ieee PD             8     90.0
Gi1/0/14  auto   on         90.0    Ieee PD             8     90.0
Gi1/0/15  auto   on         60.0    WS-C2960CPD-8PT-L   4     90.0

C93-Standalone(config-if)#
C93-Standalone(config-if)#
C93-Standalone(config-if)#int gi1/0/10
C93-Standalone(config-if)#
C93-Standalone(config-if)#
C93-Standalone(config-if)#power inline stat
C93-Standalone(config-if)#power inline static max 60000
```

Interface Gi1/0/10 is given the static power configuration of 60,000 miliwatts (mW). This is possible because there are enough remaining watts to budget.

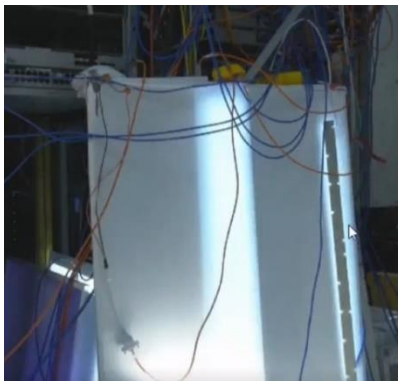
```
Module   Available     Used     Remaining
          (Watts)    (Watts)    (Watts)
------   ---------   --------   ---------
1          1545.0      685.8       859.2
Interface Admin  Oper       Power   Device              Class Max
                            (Watts)
--------- ------ ---------- ------- ------------------- ----- ----
Gi1/0/1   auto   off        0.0     n/a                 n/a   90.0
Gi1/0/2   auto   on         15.4    Ieee PD             3     90.0
Gi1/0/3   auto   off        0.0     n/a                 n/a   90.0
Gi1/0/4   auto   off        0.0     n/a                 n/a   90.0
Gi1/0/5   static on         30.0    Ieee PD             4     30.0
Gi1/0/6   auto   on         30.0    Ieee PD             4     90.0
Gi1/0/7   auto   on         30.0    WS-C3560CPD-8PT-S   4     90.0
Gi1/0/8   auto   on         90.0    Ieee PD             8     90.0
Gi1/0/9   auto   on         90.0    Ieee PD             8     90.0
Gi1/0/10  static power-deny 60.0    n/a                 n/a   60.0
Gi1/0/11  auto   off        0.0     n/a                 n/a   90.0
Gi1/0/12  auto   on         15.4    CIVS-IPC-6500PD     0     90.0
Gi1/0/13  auto   on         90.0    Ieee PD             8     90.0
Gi1/0/14  auto   on         90.0    Ieee PD             8     90.0
Gi1/0/15  auto   on         60.0    WS-C2960CPD-8PT-L   4     90.0
```

Observe interface Gi1/0/10 receiving a specific amount of power. Power-deny is shown because the device requires 90W but is only receiving 60W due to static power configuration.

5.7 PoE & Data Testing

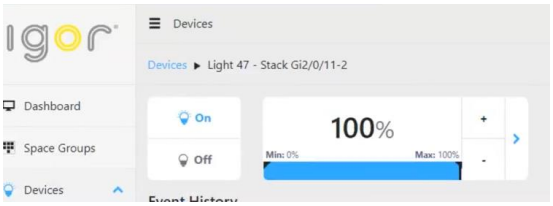
5.7.1 Controlling Lights Powered by PoE

We were given a brief tour and demonstration on the lighting management interface (third-party vendor). The application is vendor specific and works through the lighting itself. We saw the power usage of the lights increase as the light intensity was increased via the vendor management software. A single Ethernet cable, between the PoE node and the switch port, provided 90W of power to the lights/sensors. The lights/sensors were daisy chained to the PoE node and required data traffic to be discovered and managed from the vendor's controller software. Power efficiency is based on cable gauge, maximum power drawn by the PD, and cable distance.



```
Actual consumption
Measured at the port(watts) (Alt-A,B): 10.6
Maximum Power drawn by the device since powered on: 72.0
```

Light displayed only utilizing 10.6 watts.



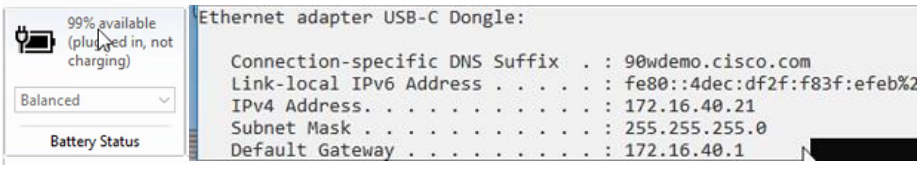
Using the IGOR management interface, we were able to increase the power to the device.

```
Actual consumption
Measured at the port(watts) (Alt-A,B): 70.8
Maximum Power drawn by the device since powered on: 72.0
```

After increasing power, light intensity increased, and the switch recognized power usage – shown as 70W.

5.7.2 90W Capable USB-C Dongle

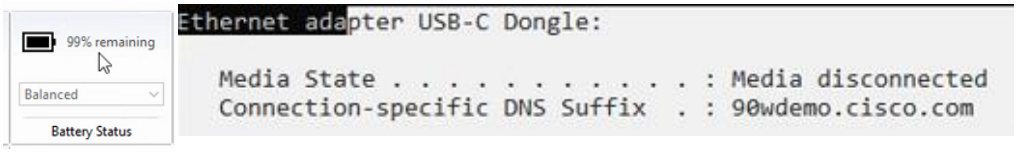
With 802.3bt Type 4, 90W becoming a standard, USB-C dongles can be leveraged to provide network connectivity to the laptops, along with charging them at the same time via the Ethernet cables. This adapter provides the flexibility of charging the laptops, along with network connectivity. We observed the USB-C dongle successfully negotiating 90W and charging the laptop simultaneously. We also observed the laptop starting to discharge as soon as the USB-C dongle was disconnected.



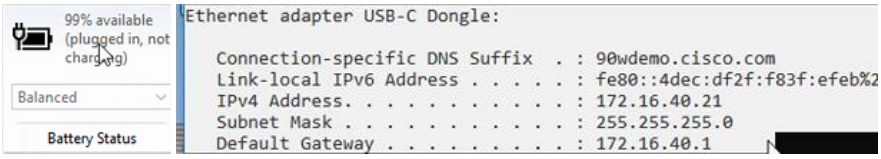
Laptop power is shown as plugged in and attempting to charge the laptop. The CLI (command line interface) displays the adapter being recognized by the laptop as shown by the assigned IP via DHCP.

```
C9300-Stack#sh power inline g3/0/11 detail
 Interface: Gi3/0/11
 Inline Power Mode: auto
 Operational status (Alt-A,B): on,on
 Device Detected: yes
 Device Type: Ieee PD
 Connection Check: SS
 IEEE Class (Alt-A,B): 8
 Physical Assigned Class (Alt-A,B): 8
 Discovery mechanism used/configured: Ieee and Cisco
 Police: off

 Power Allocated
 Admin Value: 90.0
 Power drawn from the source: 90.0
 Power available to the device: 90.0
 Allocated Power (Alt-A,B): 90.0

 Actual consumption
 Measured at the port(watts) (Alt-A,B): 13.1
 Maximum Power drawn by the device since powered on: 66.9

 Absent Counter: 0
 Over Current Counter: 0
 Short Current Counter: 0
 Invalid Signature Counter: 0
 Power Denied Counter: 0

 Power Negotiation Used: None
 LLDP Power Negotiation       --Sent to PD--      --Rcvd from PD--
 Power Type:                  -                    -
 Power Source:                -                    -
 Power Priority:              -                    -
 Requested Power(W):          -                    -
 Allocated Power(W):          -                    -

Four-Pair PoE Supported: Yes
Spare Pair Power Enabled: Yes
Four-Pair PD Architecture: Shared
```

Successful 802.3bt negotiation between the USB-C dongle (PD) and the switch (PSE).



With the USB-C dongle turned off and removed from the laptop, we observed disconnection. The laptop was no longer charging.



The USB-C dongle was turned back on, as shown by the different assigned IP address. The laptop resumed charging and network connectivity was established.

Cisco Connectivity Advantages:

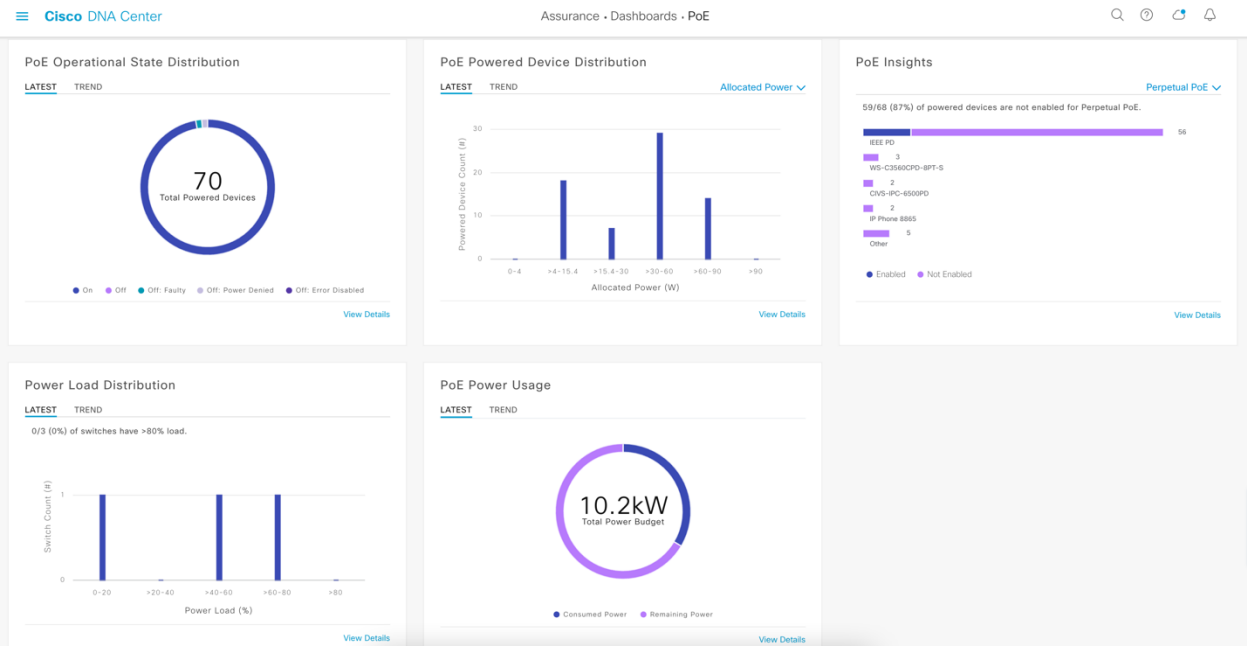
- Cisco UPOE+ negotiation occurs at the hardware. LLDP complements by adjusting the power as needed once the initial negotiation is done.
- Perpetual PoE continues to provide power to the endpoints during a soft reload (e.g., for an upgrade, during a crash).
- Fast PoE restores power to devices based on memory, observed within 23 seconds.
- Load Shedding prioritizes critically functioning end points to remain powered up during power failure events.
- Static Power configurations allows users to assign custom power limitations.
- Partnership and integration with third-party vendors provide granular control of power to the endpoints and intensity via the vendor management interface.
- The USB-C dongle provides both power and network connectivity to laptop devices.

6.0 PoE Analytics and Assurance

Network configuration and management is expensive. Manual Network Configuration and management can result in misconfigurations, inconsistencies and high risk environment leading to stalled digital transformation. The Cisco DNA Center is a network controller and management dashboard that can automate the deployment, connectivity, and lifecycle of the infrastructure. Cisco DNA Assurance enables every point on the network to become a sensor, sending continuous, streaming telemetry on application performance and user connectivity in real time. Telemetry with contextual data provides visibility to the network and analytic engines to find any anomalies and pinpoint causes of issues. Guided remediation is available to assist and guide users to resolve these issues. The dashboard is very user-friendly with graphical information. To utilize it, customers would need a Cisco DNA Center ready network and a Cisco Catalyst 9000.

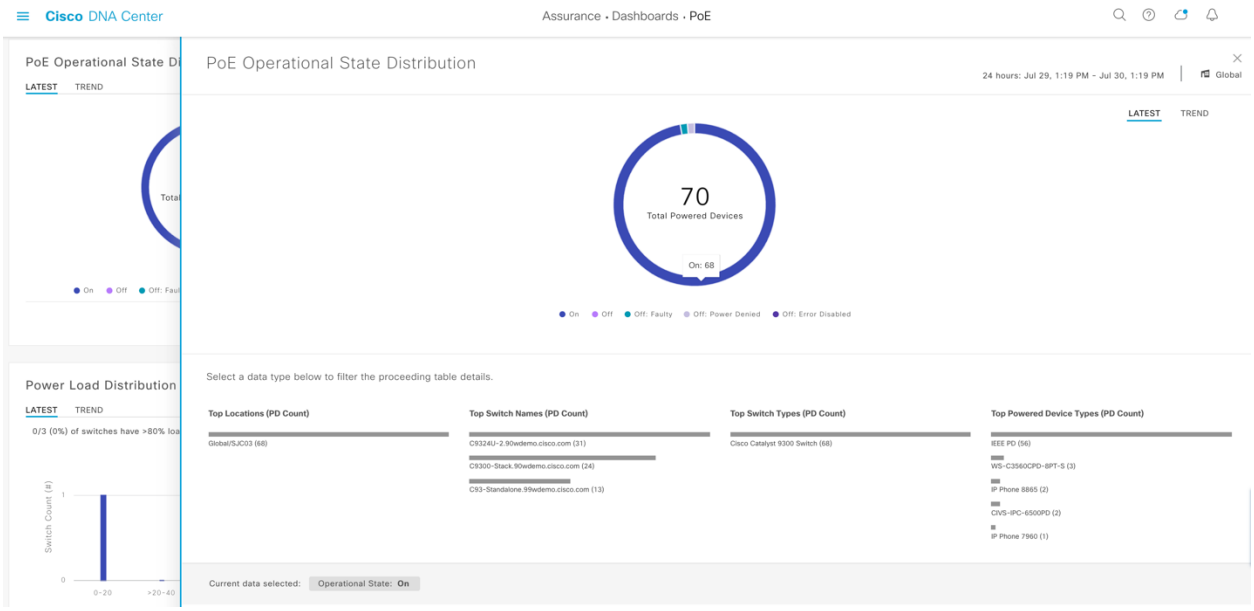
6.1 Cisco DNA Center for PoE Assurance

The Cisco DNA Center PoE Assurance dashboard provides overall PoE usage within the network to assist customers with planning, monitoring, and troubleshooting the network.

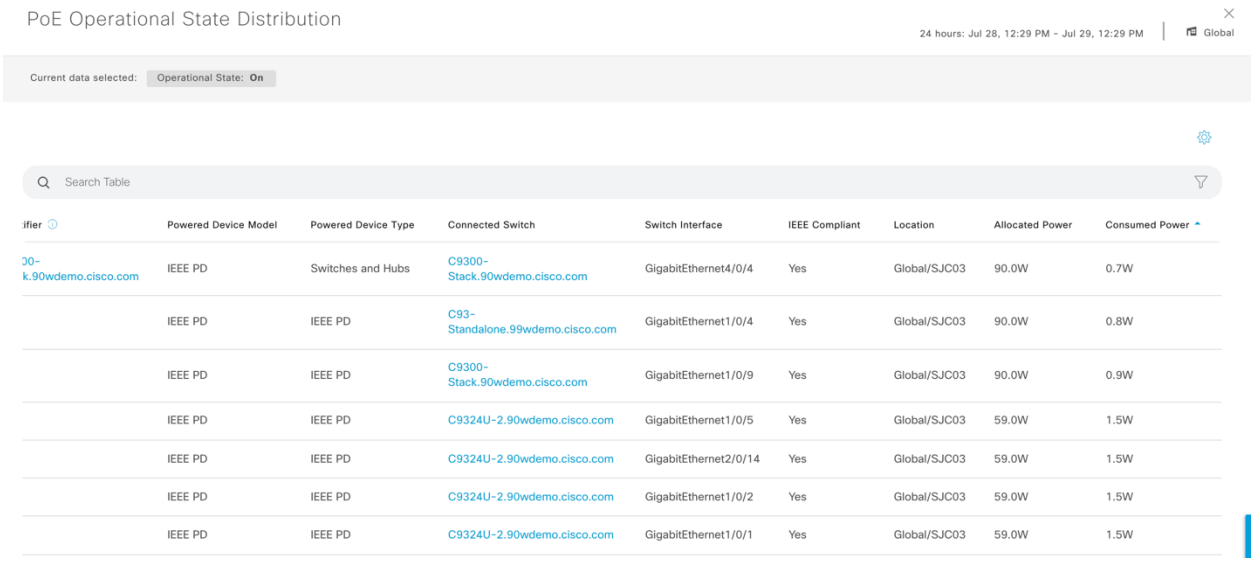


The dashboard at the Cisco DNA Center provides a holistic view of the PoE usage within the network.

6.2 PoE Operational State Distribution



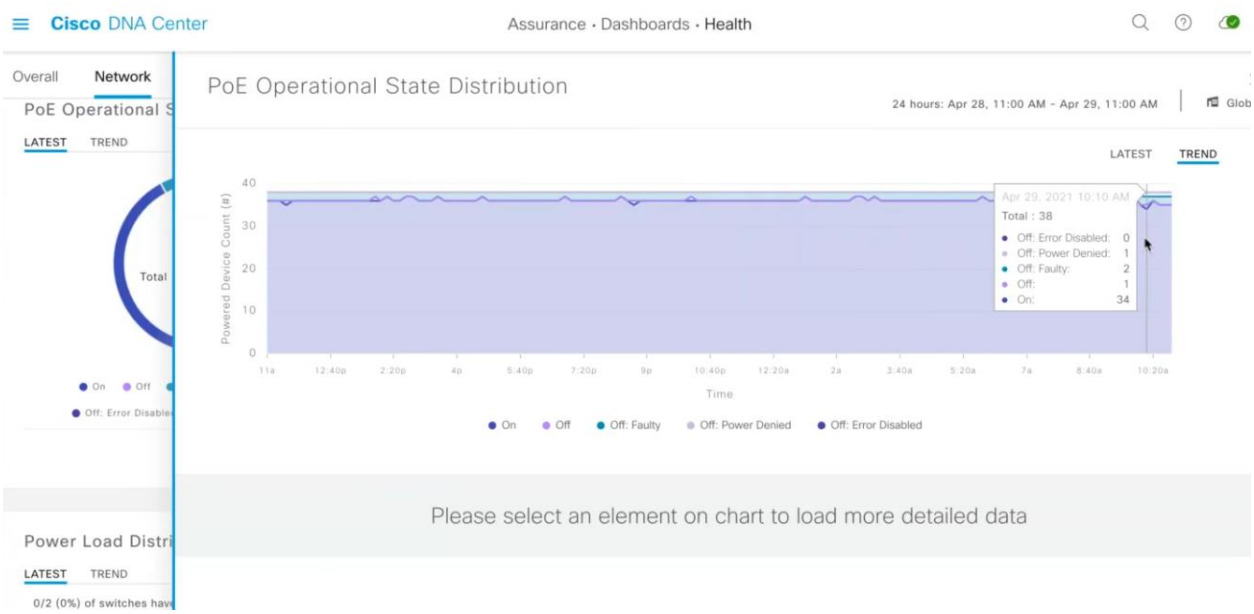
We were able to see total powered devices, along with trends and other details of connected devices. Interacting with the figure further displayed detailed device information.



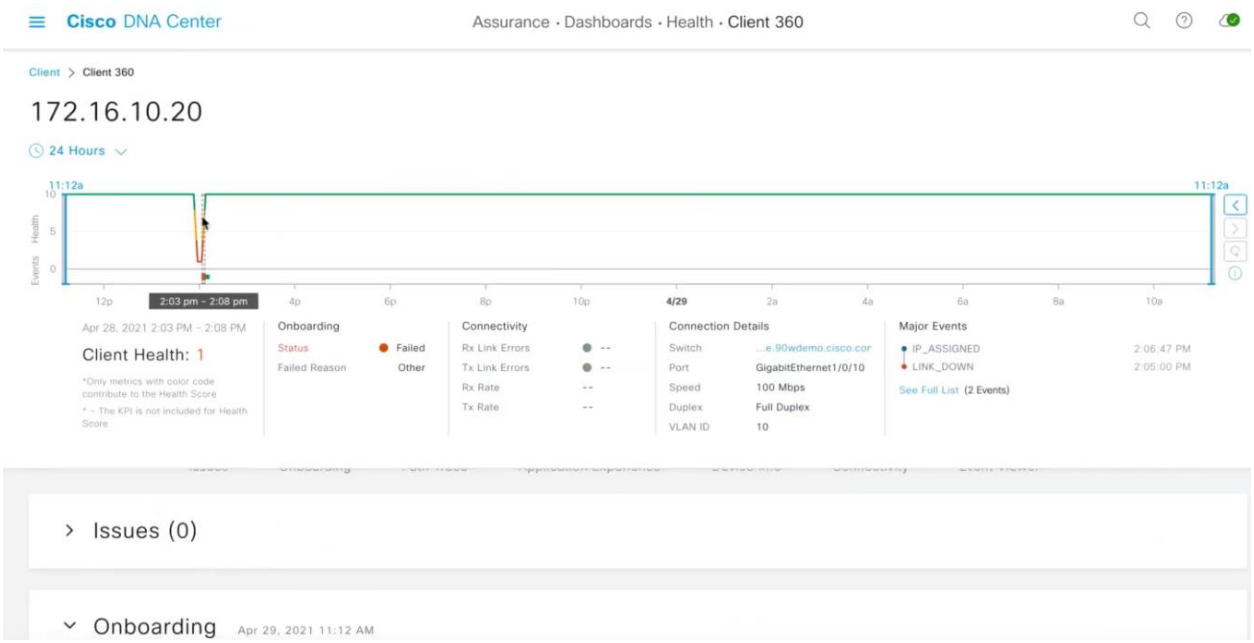
ifier	Powered Device Model	Powered Device Type	Connected Switch	Switch Interface	IEEE Compliant	Location	Allocated Power	Consumed Power
00-k.90wdemo.cisco.com	IEEE PD	Switches and Hubs	C9300-Stack.90wdemo.cisco.com	GigabitEthernet4/0/4	Yes	Global/SJC03	90.0W	0.7W
	IEEE PD	IEEE PD	C93-Standalone.99wdemo.cisco.com	GigabitEthernet1/0/4	Yes	Global/SJC03	90.0W	0.8W
	IEEE PD	IEEE PD	C9300-Stack.90wdemo.cisco.com	GigabitEthernet1/0/9	Yes	Global/SJC03	90.0W	0.9W
	IEEE PD	IEEE PD	C9324U-2.90wdemo.cisco.com	GigabitEthernet1/0/5	Yes	Global/SJC03	59.0W	1.5W
	IEEE PD	IEEE PD	C9324U-2.90wdemo.cisco.com	GigabitEthernet2/0/14	Yes	Global/SJC03	59.0W	1.5W
	IEEE PD	IEEE PD	C9324U-2.90wdemo.cisco.com	GigabitEthernet1/0/2	Yes	Global/SJC03	59.0W	1.5W
	IEEE PD	IEEE PD	C9324U-2.90wdemo.cisco.com	GigabitEthernet1/0/1	Yes	Global/SJC03	59.0W	1.5W

More details are provided about the powered devices, including the device model, switch interface, IEEE compliance, allocated power, and location after interacting with the circle figure. Users can filter the device for a quick search.

Clicking on the device status showed all the endpoints in that status. Here clicking on the “on” state pulled up all the endpoints that are up and operational. This table also showed the Allocated Power (negotiated power) and Consumed Power (real time power usage) at the port.

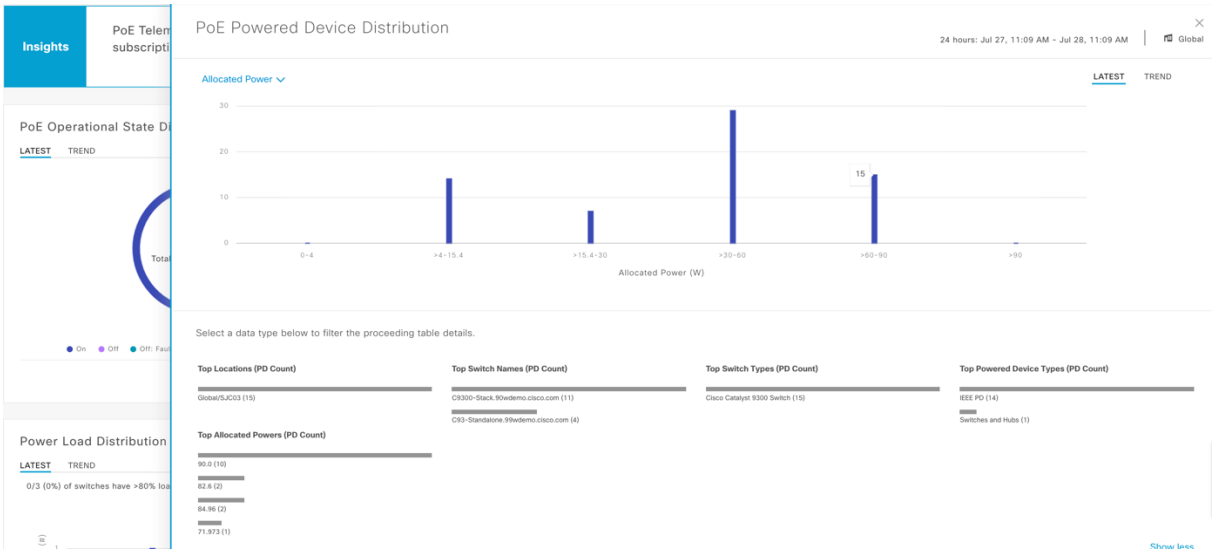


By clicking trends, users can view the snapshot of the total endpoints at any particular point of time. It also shows the status of devices over time and can help with quick glances of any device failures. As shown, we can view an instance during the timeline where a device was being denied power.

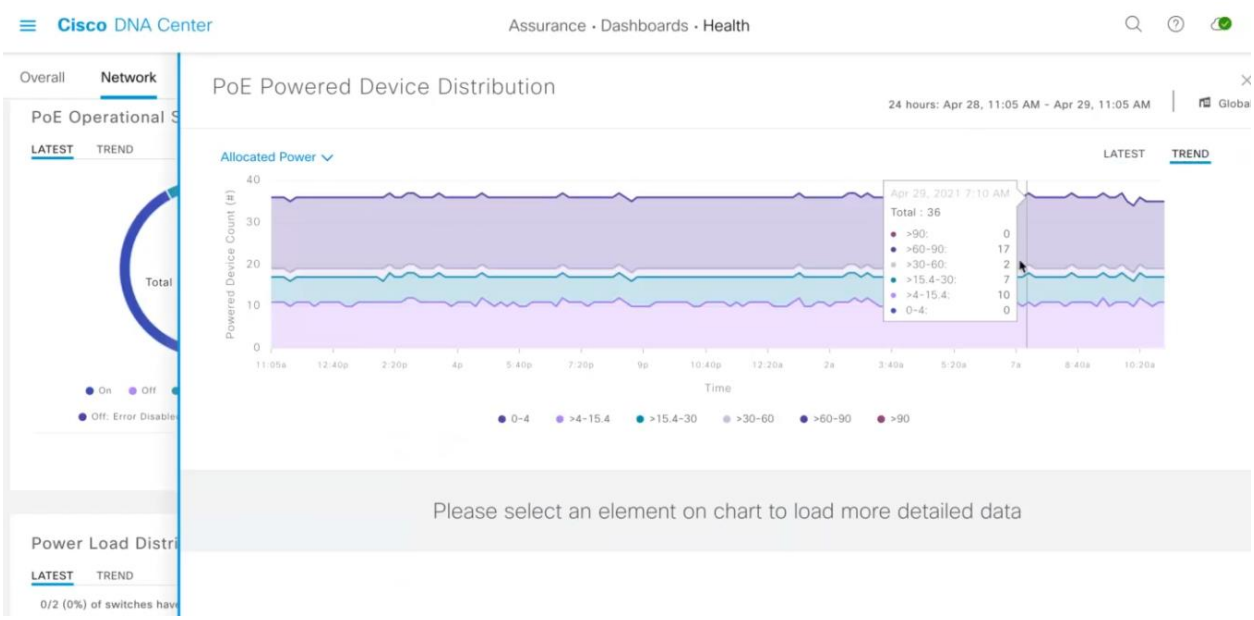


Clicking on individual devices gives a 'Client 360' timeline of events, path tracing, and logs. We can view a timeline of the device to view failed states and reasons behind it.

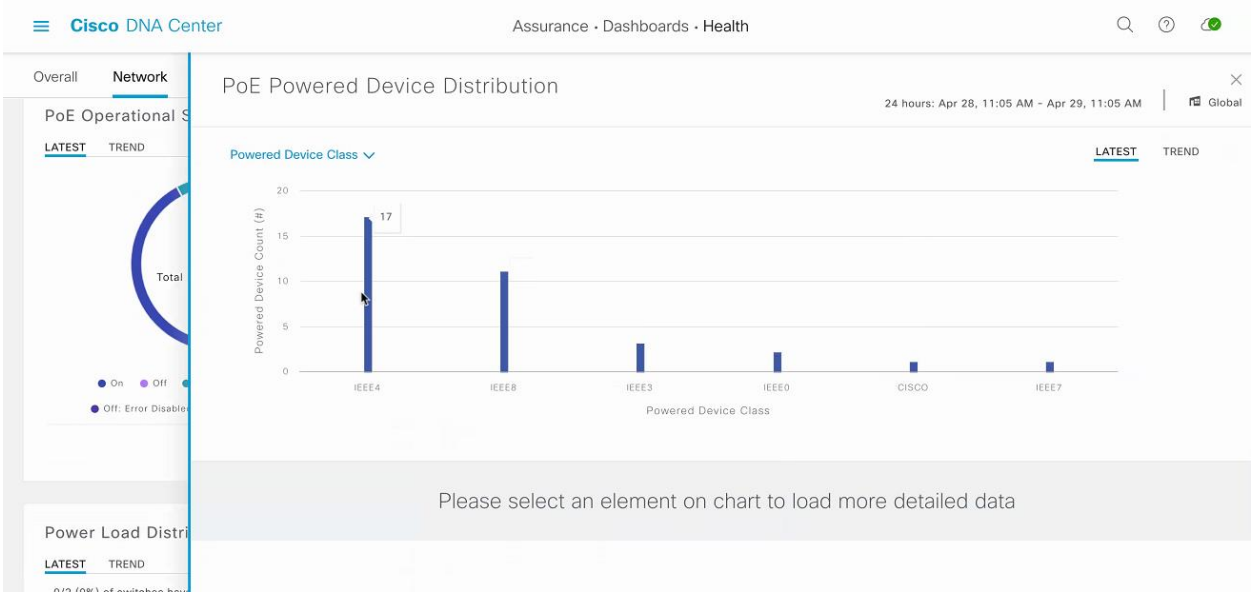
6.3 PoE Powered Device Distribution



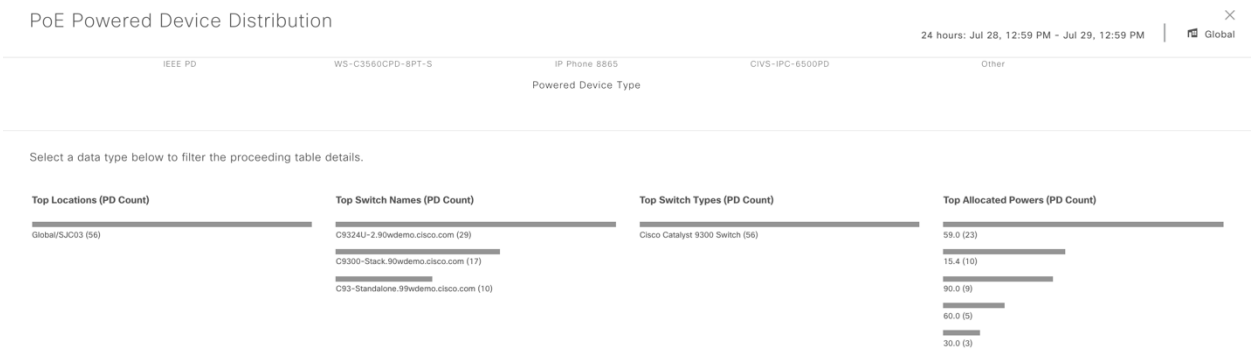
Cisco DNA Center provides a view of PoE endpoints in terms of PoE that an endpoint negotiated during power-on. As shown, there are 15 devices that have power allocated between 60 to 90W. It showed the total count of all the endpoints based on the power allocated to them.



We were able to easily view trends and timelines on devices and instantly get a snapshot on the number of devices connected to the network and what class they negotiated.



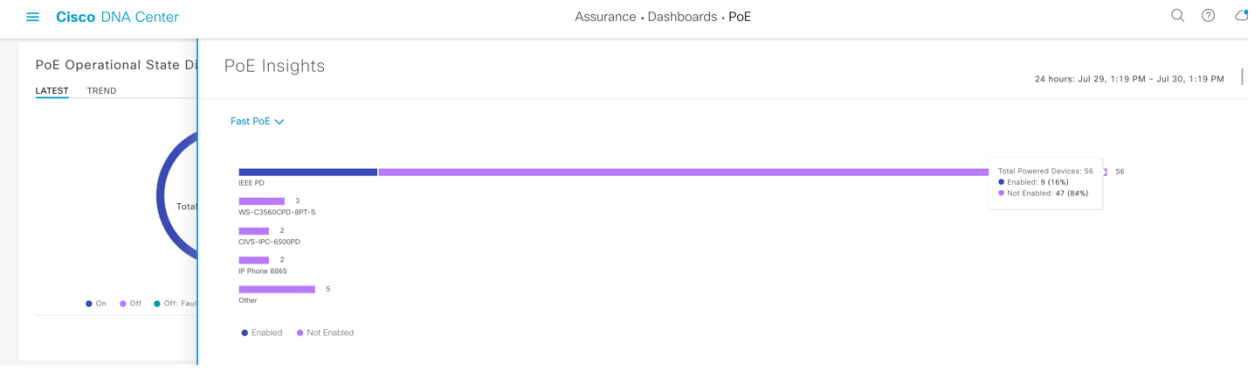
In the PoE Powered Device Distribution, users can view a categorization of devices separated by classes defined in 802.3bt spec. Clicking on a category gives further detail of the devices.



Users can also see further details like top Location, top list of switches by number of endpoints, and power allocated data in ascending order.

6.4 PoE Insights

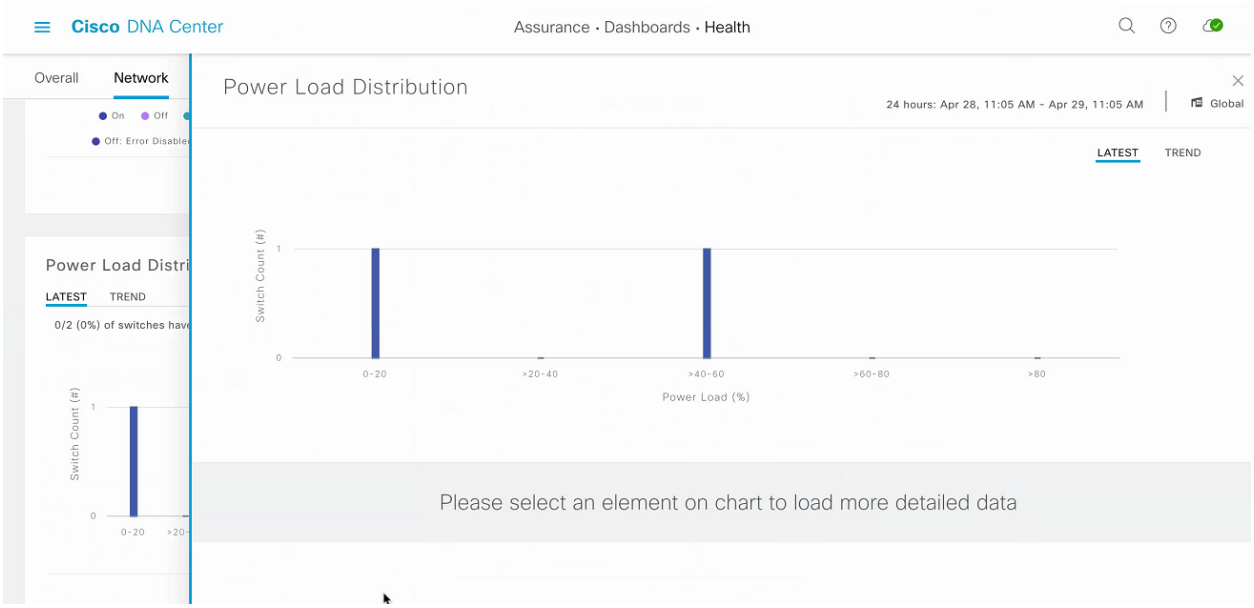
PoE Insights offers a quick glance of which PoE devices are enabled with/without Perpetual PoE.



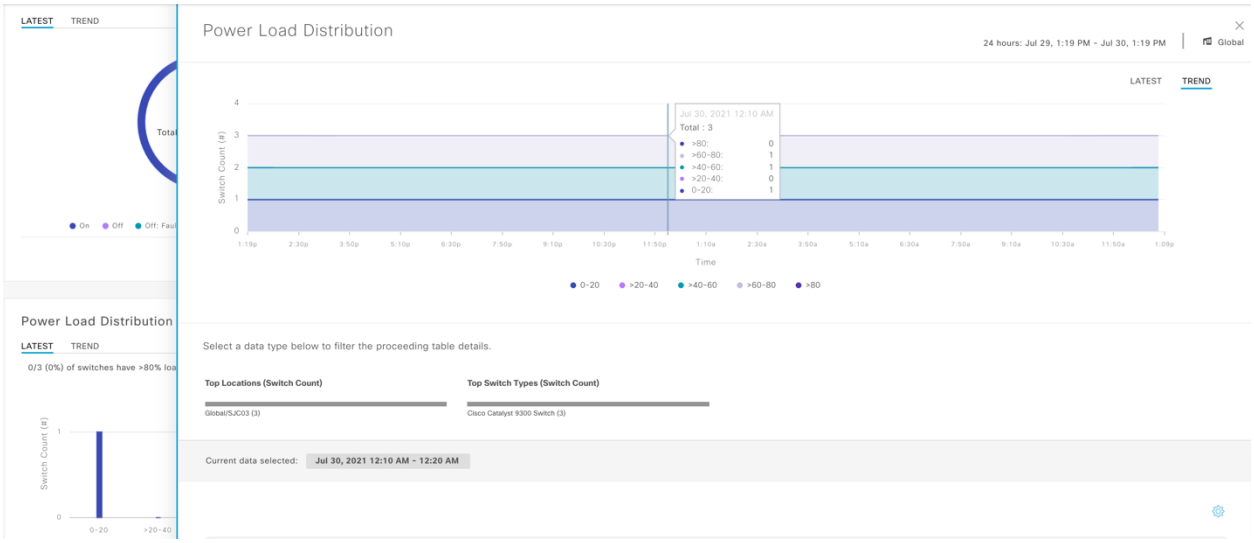
PoE Insights also provides an overview of PoE devices enabled with/without Fast PoE.

PoE devices can also be organized based on their IEEE Compliance status.

6.5 Power Load Distribution



Users can view power load distribution across all switches within the network—useful for planning watt budget or the addition of PoE devices.

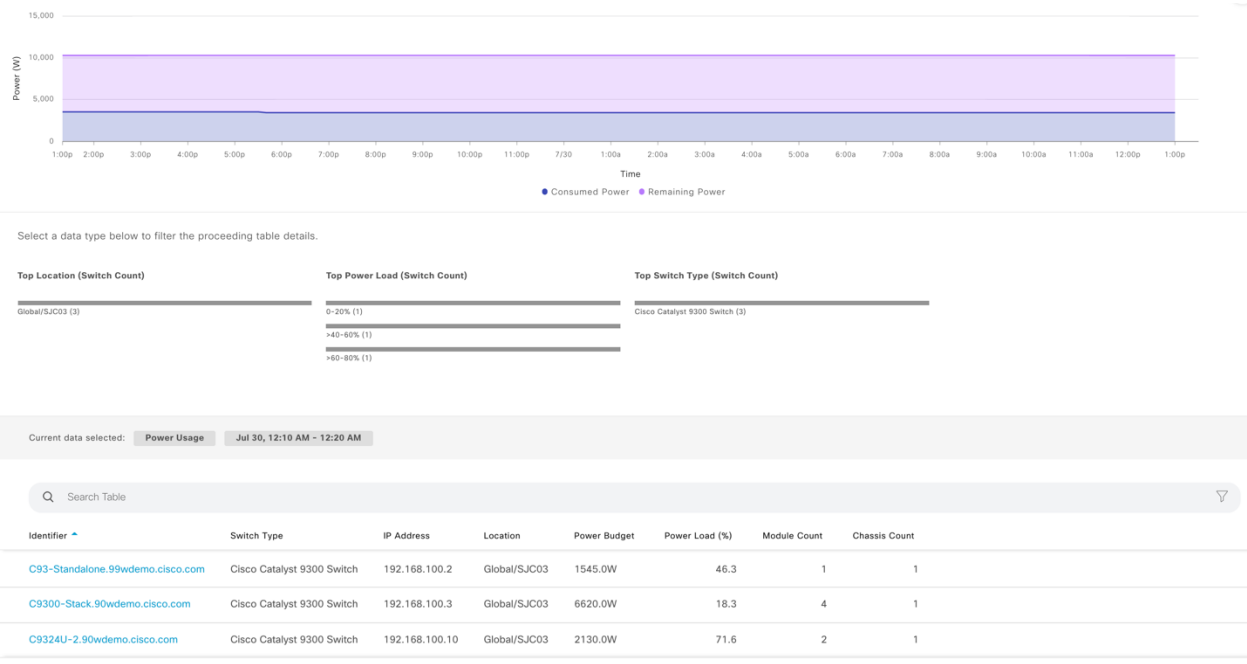


The trend tab shows the history of the load distribution across the switches. Above, we see one 9300 switch taking over 20 percent load, another 9300 between 40-60 percent, and another 9300 between 60-80 percent load.

6.6 PoE Power Usage

PoE Usage dashboard showed the Total Power Budget across all the switches in the network.

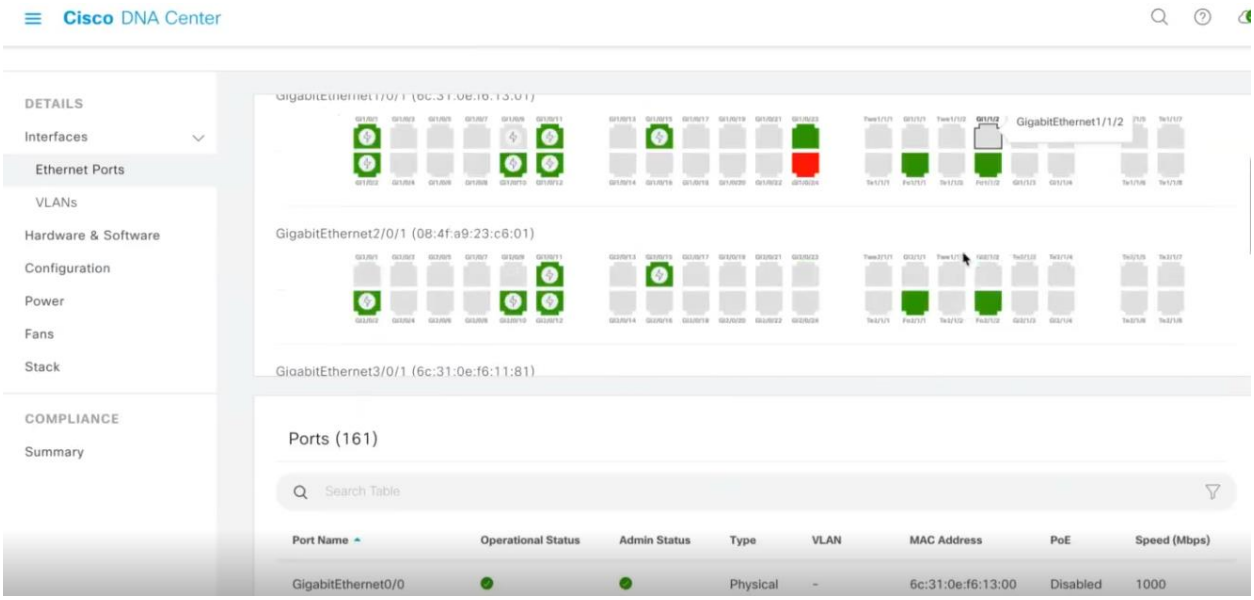
The PoE power usage provided information about the Total PoE that has been consumed by all the switches and the available PoE.



Identifier	Switch Type	IP Address	Location	Power Budget	Power Load (%)	Module Count	Chassis Count
C93-Standalone.99wdemo.cisco.com	Cisco Catalyst 9300 Switch	192.168.100.2	Global/SJC03	1545.0W	46.3	1	1
C9300-Stack.90wdemo.cisco.com	Cisco Catalyst 9300 Switch	192.168.100.3	Global/SJC03	6620.0W	18.3	4	1
C9324U-2.90wdemo.cisco.com	Cisco Catalyst 9300 Switch	192.168.100.10	Global/SJC03	2130.0W	71.6	2	1

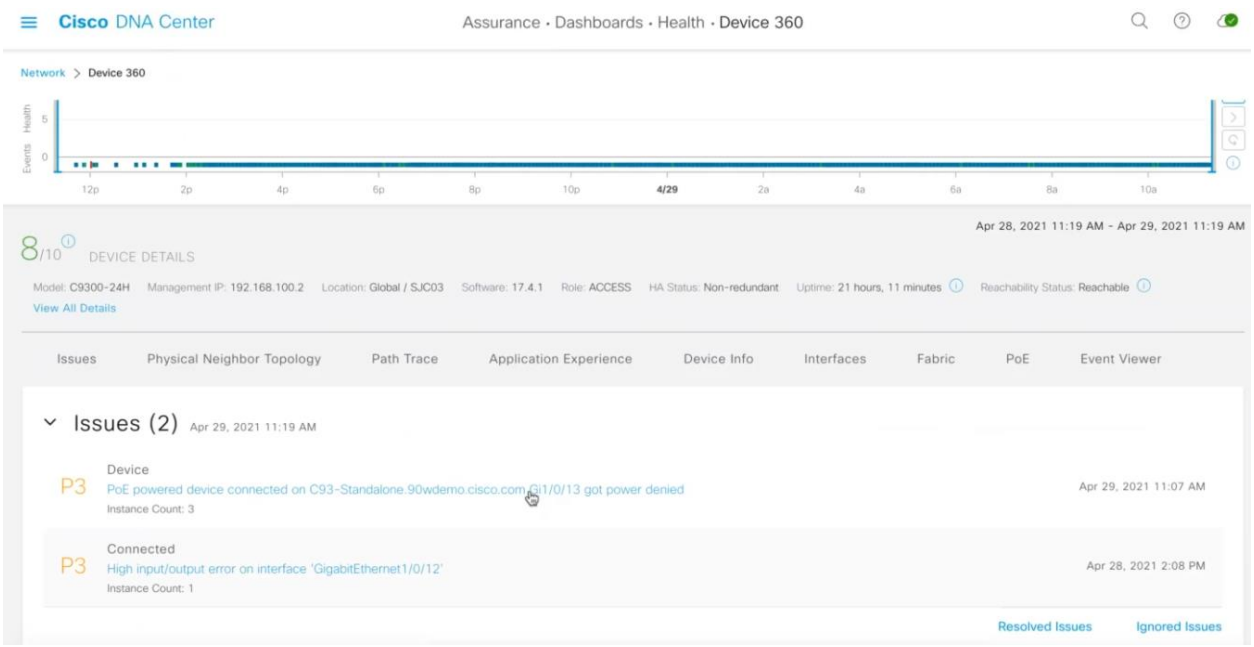
The Trends options provided real-time Power Usage (available and consumed) snapshot at a particular point of time along with Power Budget of each switch.

6.7 PoE Port Verification on Switch

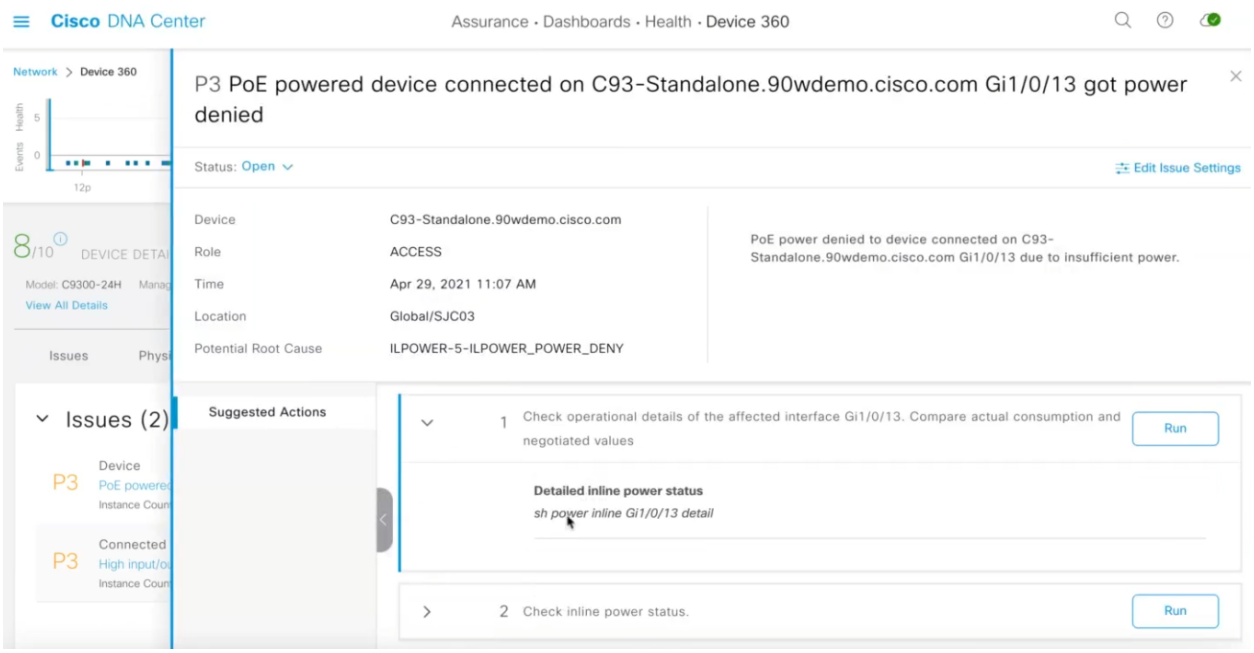


Under Interfaces → Ethernet Ports, users can visually capture how many PoE enabled devices are on the switch, navigating on the switch itself under "Provision". As shown, we observed the Ethernet ports of the switch, PoE ports, and which ports are providing PoE to the endpoints.

6.8 Troubleshooting PoE Catalyst 9000 Switches



Clicking on a network issue will bring up a log that details the problem.



Clicking on the specified issue will show the user any suggested actions that can be taken to resolve the issue and the steps to take to complete the actions.

Cisco Assurance Advantages:

- Cisco DNA Center dashboard provides a holistic view for planning, monitoring, and troubleshooting PoE devices and understanding PoE usage within the network.
- Cisco DNA Center allows users to view PoE Operational State Distribution with powered device details, trends, event timelines, PoE categorization, and classifications.
- The PoE Insights window offers quick glances at devices enabling PPoE, Fast PoE, IEEE compliance, and UPOE+.
- Users can view power load distribution for power budgeting and device additions.
- PoE devices are viewable by port on the switch via a color-coded visual map.
- Cisco DNA Center gives a detailed look at device issues and offers remediation suggestions.

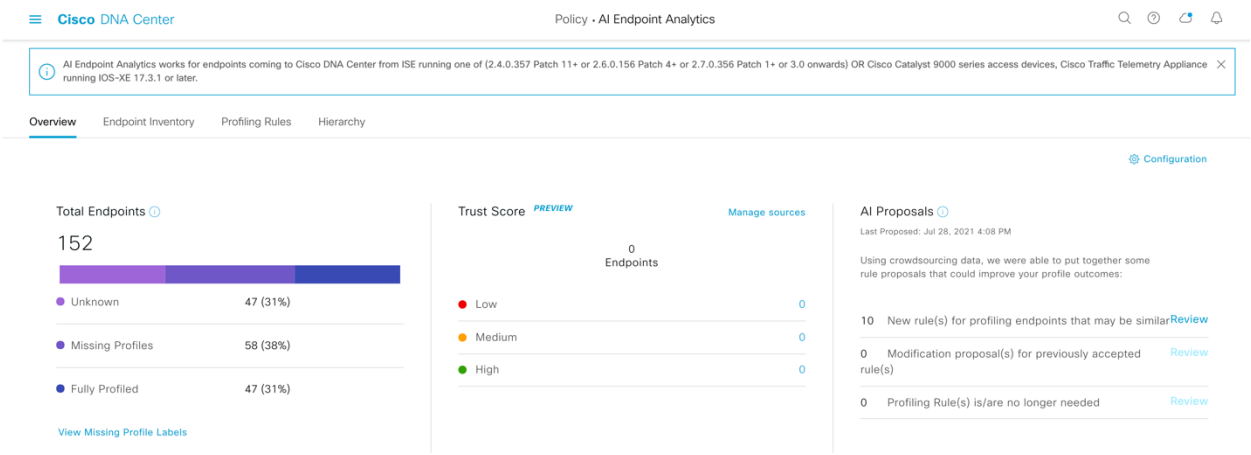
7.0 Endpoint Analytics and Security

7.1 Endpoint Analytics

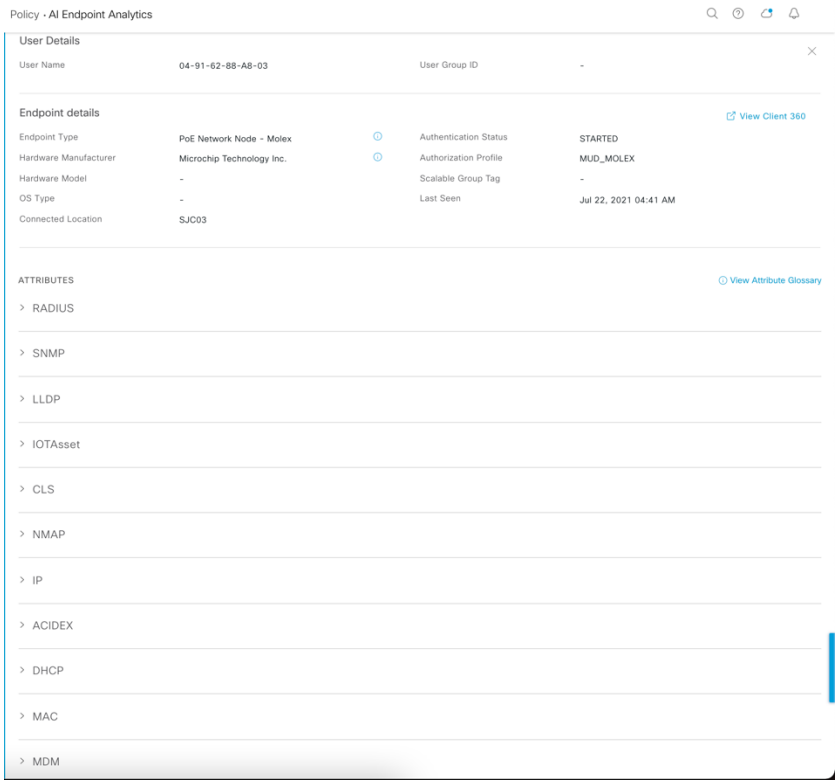
Cisco AI (Artificial Intelligence) Endpoint Analytics is a next generation endpoint visibility feature, equipped with AI-driven analytics and deep packet inspection. Endpoint Analytics uses deep packet inspection capabilities, available on the Catalyst 9300/9400 switches, to optimally profile endpoints using Multi-factor Classification – a distinctive approach to network segmentation through increased visibility. Users can also create custom profiles based on the attributes that Endpoint Analytics learns about a specific endpoint.

When classifying endpoints, Multi-factor Classification uses four independent labels: Device Type, Hardware Model, Hardware Manufacturer, and Operating System. When all four labels of an endpoint have been determined, the endpoint is classified and categorized as fully profiled.

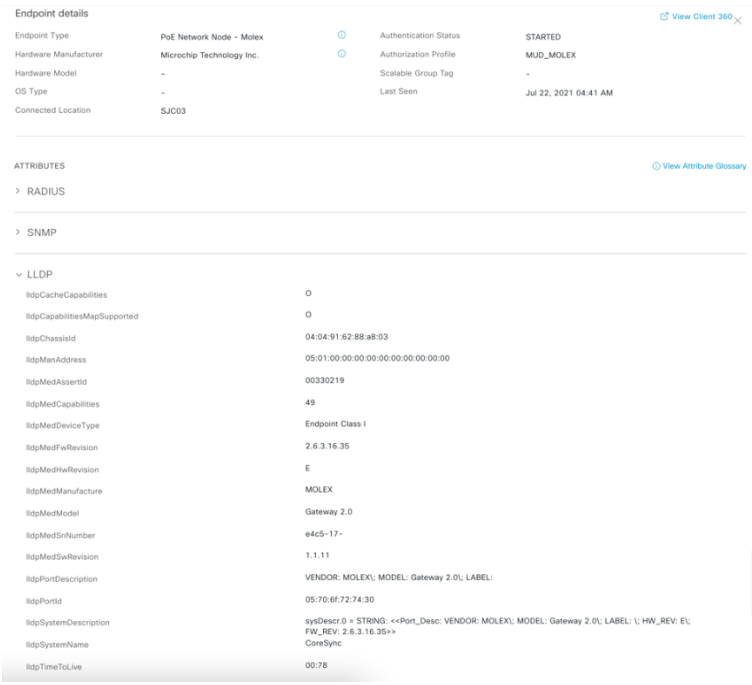
This process is done using NBAR (Network Based Application Recognition) capabilities of the Catalyst 9300/9400 switches. Switches push this information to the Cisco DNA Center, along with other features such as LLDP. The Cisco DNA Center then correlates this information and provides suggested labels for the device type. Once it goes through the Cisco DNA Center, it will try and profile the device.



The Cisco DNA Center dashboard presents an overall network view. As shown on the left, we observed 152 total devices, and 47 devices fully profiled. AI Proposals use crowdsourcing data and provide suggestions based on similar data seen on other networks. The Trust Score gives the score on how credible each device is.

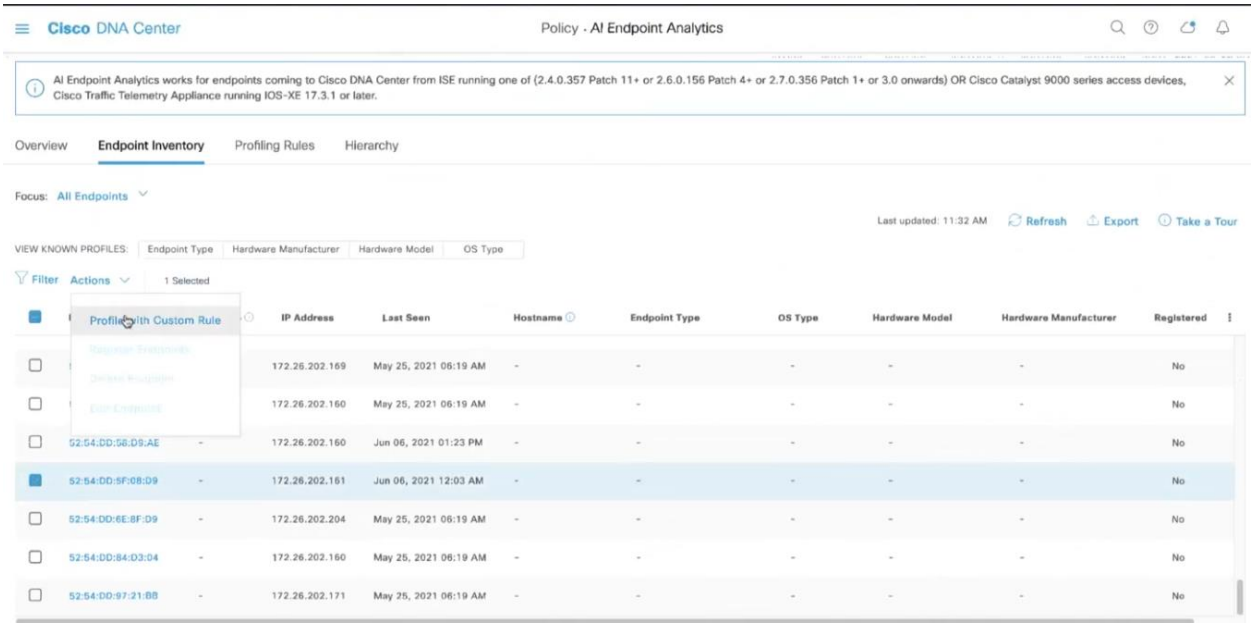


Navigating to Endpoint Inventory provides more details on endpoints. By clicking on specific endpoints, customers can view the all the attributes specific to the endpoint that Cisco DNA Center has learnt.

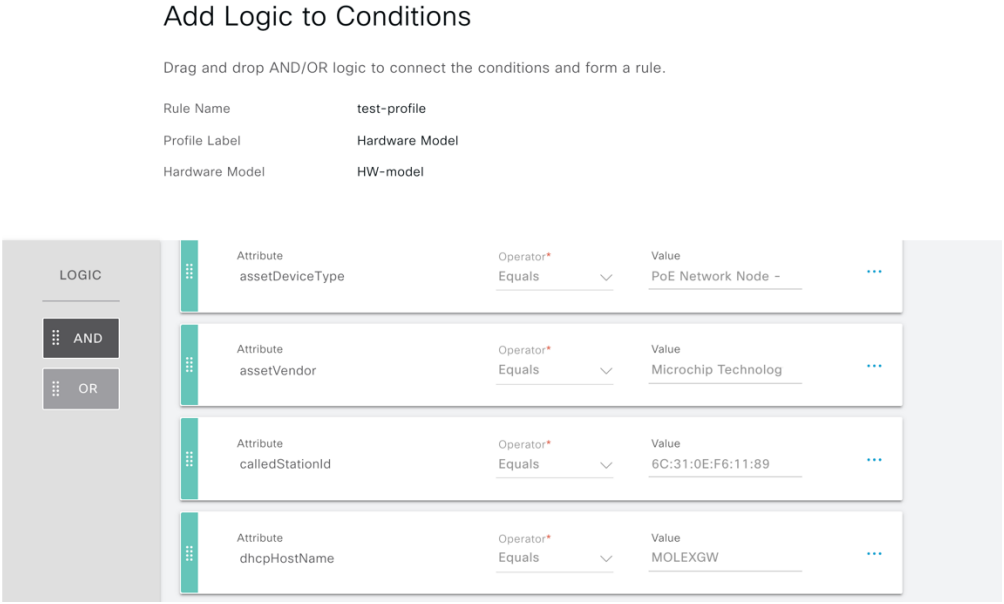


Clicking on any specific attribute shows more information about the details.

Clicking on each attribute further details that specific to the Endpoint that Cisco DNA Center has learnt:

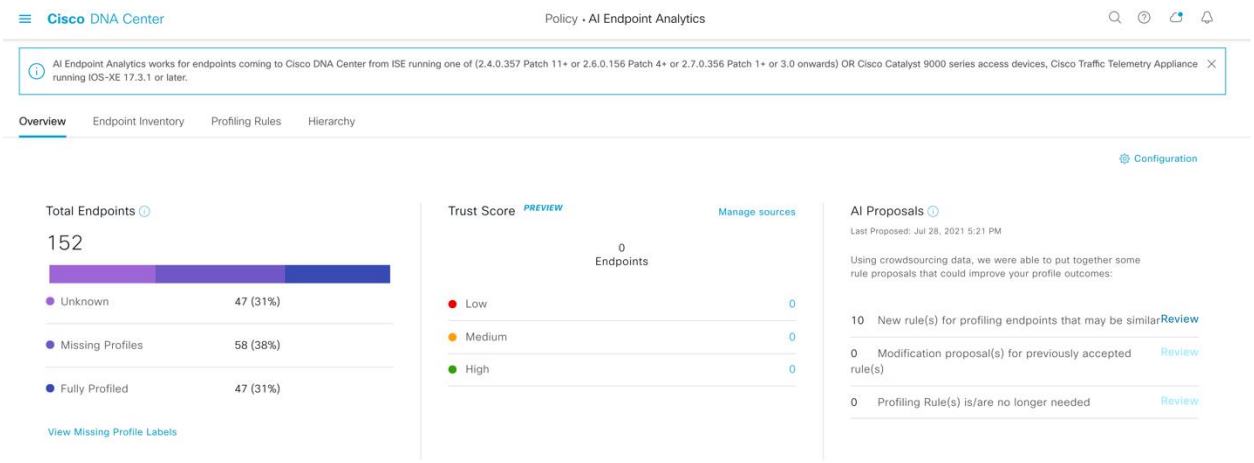


Profiling Rules are auto-generated based on the attributes that the Cisco DNA Center learns specific to that endpoint. If the Endpoint Analytics application does not have enough information to profile the endpoint, the user has the flexibility of creating a custom profiling policy based on the attributes that the Endpoint Analytics application has already seen. Any subsequent endpoint that matches this custom rule will be profiled as such.

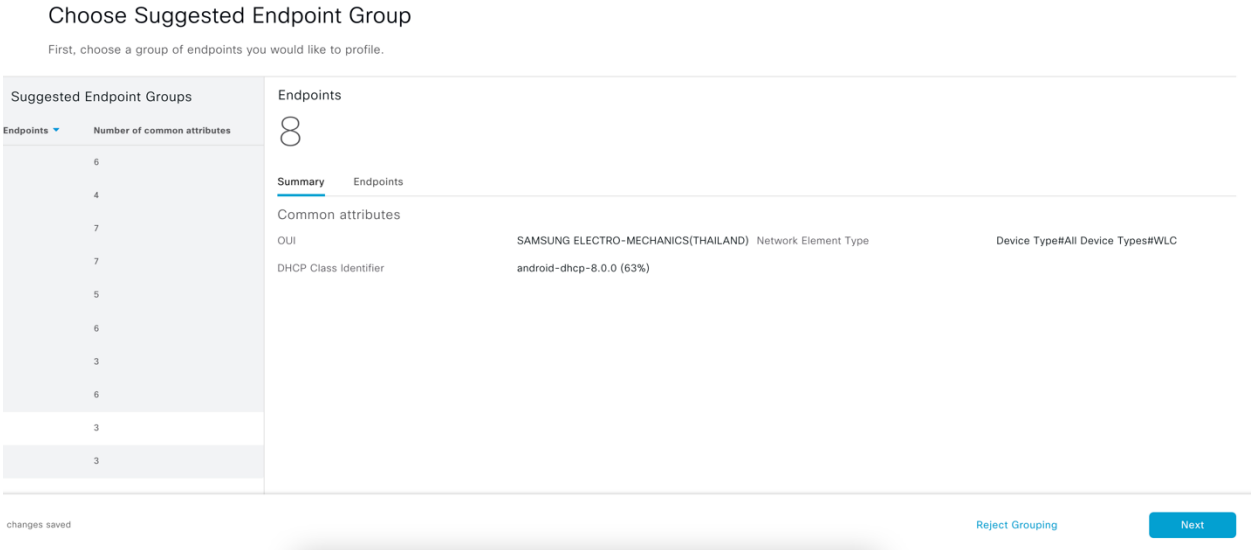


To create a manual rule, customers can click on the device by navigating back to Endpoint Inventory → Actions → Profile with Custom Rule. From here, "AND" or "OR" logic is applied to attribute conditions and add other configurations.

Cisco AI algorithms group unknown, but similar, endpoints in the network and may also suggest modifications or removals of older AI-based rules. These AI proposed rules are found in the AI Proposals section of the AI Endpoint Analytics page.



10 new rules were suggested by the AI proposals.



Eight endpoints were suggested to be grouped with above attributes. User can either proceed next to create a profile or may reject as needed. This functionality saves customers time by auto-suggesting the profiles from the information that has been learnt via crowdsourcing.

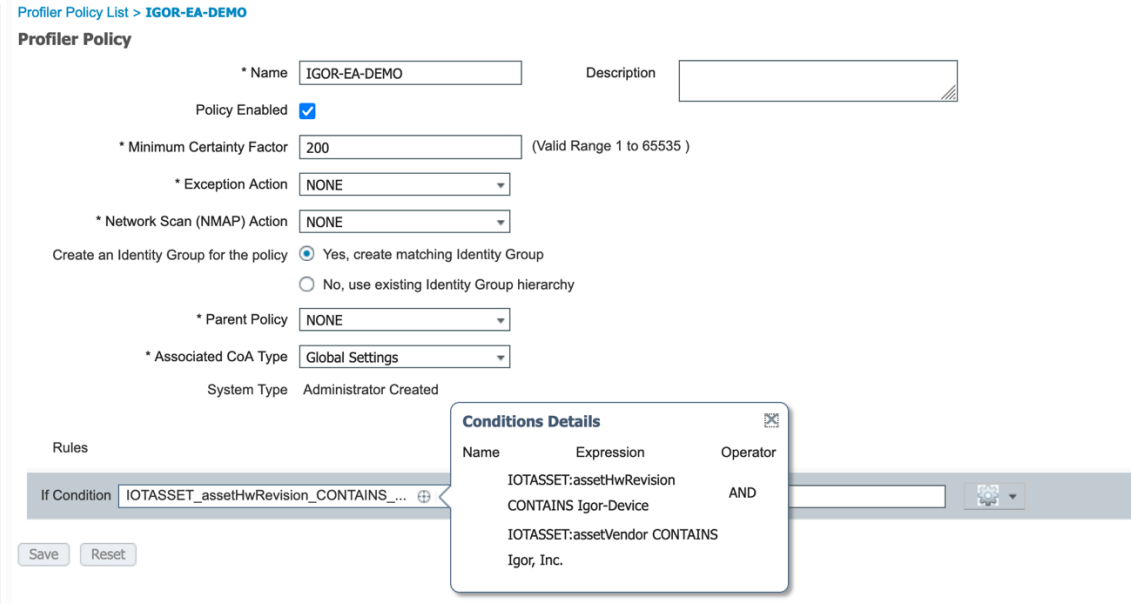
7.2 Secure Endpoints with ISE

Cisco demonstrated how the Endpoint Analytics profiling data can be used to secure the endpoints by segmenting the network.

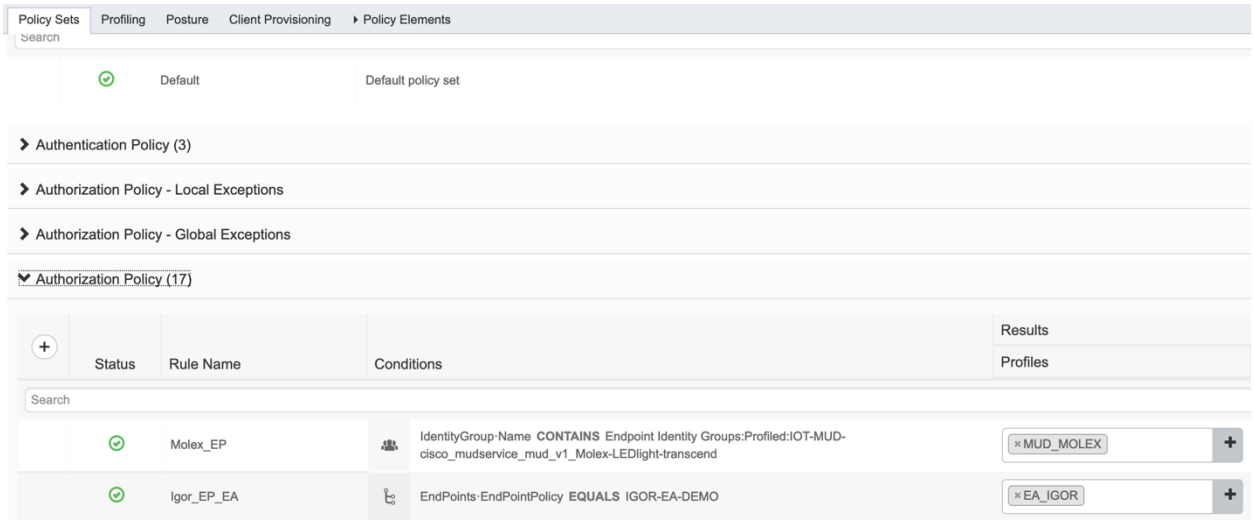
Cisco ISE has been integrated with the Cisco DNA Center so that endpoint profiling information can be relayed to the ISE to create policies.

Cisco ISE allows customers to provide highly secure network access to users and devices. It helps customers gain visibility into what is happening in the network, such as who is connected, and which applications are installed and running.

To test this, we have used a lighting endpoint powered via UPOE+ on the switch.



A policy was predefined on the Cisco ISE using the attributes that were learnt from Endpoint Analytics.

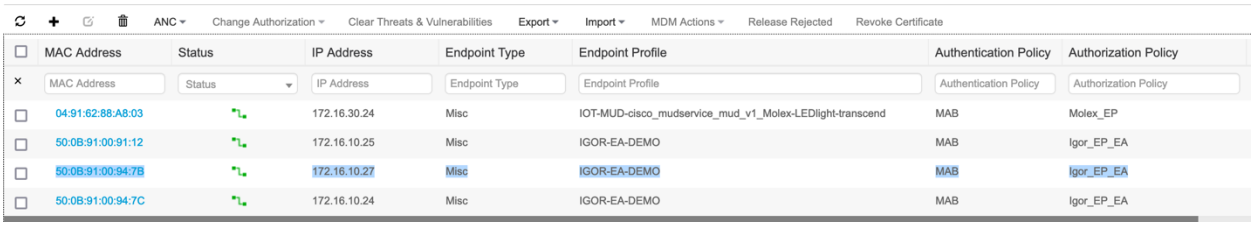


An authorization profile was configured to dynamically push an access list onto the port of the connected lighting endpoint.

Initially the port was in shut down state:

```
C9300-Stack#sh int g4/0/12
GigabitEthernet4/0/12 is administratively down, line protocol is down (disabled)
  Hardware is Gigabit Ethernet, address is 6c31.0ef6.2e0c (bia 6c31.0ef6.2e0c)
  Description: IGOR 2 Nodes Daisy Chain
  MTU 9100 bytes, BW 100000 Kbit/sec, DLY 100 usec,
     reliability 255/255, txload 1/255, rxload 1/255
```

MAB (MAC Authentication Bypass) was used here for authentication. Upon successful authentication, we noticed the endpoint on the ISE Active endpoints dashboard:



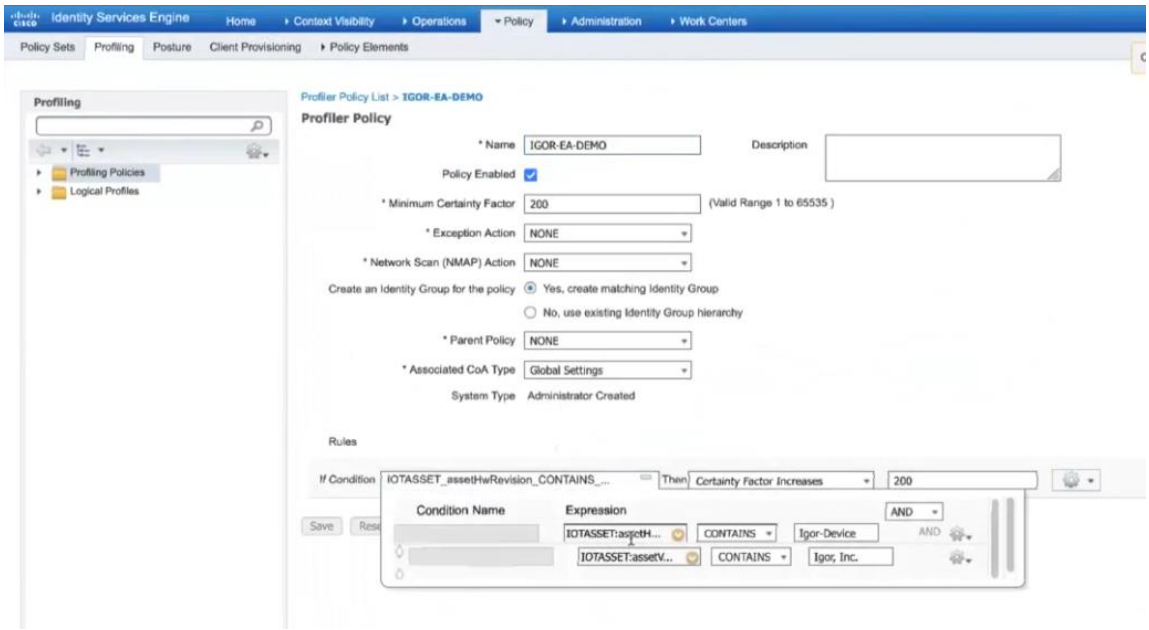
The ISE displays four active endpoints – the highlighted one is the lighting endpoint under test, and we see it successfully associated to the endpoint profile.

The associated profile was successfully pushed to the switchport where the endpoint was connected:

```
C9300-Stack#sh access-session interface g4/0/12 details
            Interface:  GigabitEthernet4/0/12
               IIF-ID:  0x19BDFE73
          MAC Address:  500b.9100.947b
         IPv6 Address:  fe80::520b:91ff:fe00:947b
         IPv4 Address:  Unknown
            User-Name:  50-0B-91-00-94-7B
               Status:  Authorized
               Domain:  DATA
      Oper host mode:  multi-auth
     Oper control dir:  both
      Session timeout:  N/A
    Common Session ID:  0364A8C00001FC08EFBCE89B
      Acct Session ID:  0x00000010
               Handle:  0x4d00034f
      Current Policy:  mab


Server Policies:
              ACS ACL: xACSACLx-IP-IGOR_ACL-60bdba40


Method status list:
       Method           State
          mab           Authc Success
```

We verified the ACL and a dynamic ACL was successfully pushed to the port, which limited access to one specific subnet and the controller:

```
C9300-Stack#sh ip access-lists xACSACLx-IP-IGOR_ACL-60bdba40
Extended IP access list xACSACLx-IP-IGOR_ACL-60bdba40
    1 permit ip any 172.16.10.0 0.0.0.255
    2 permit ip any host 172.16.95.101
C9300-Stack#
```



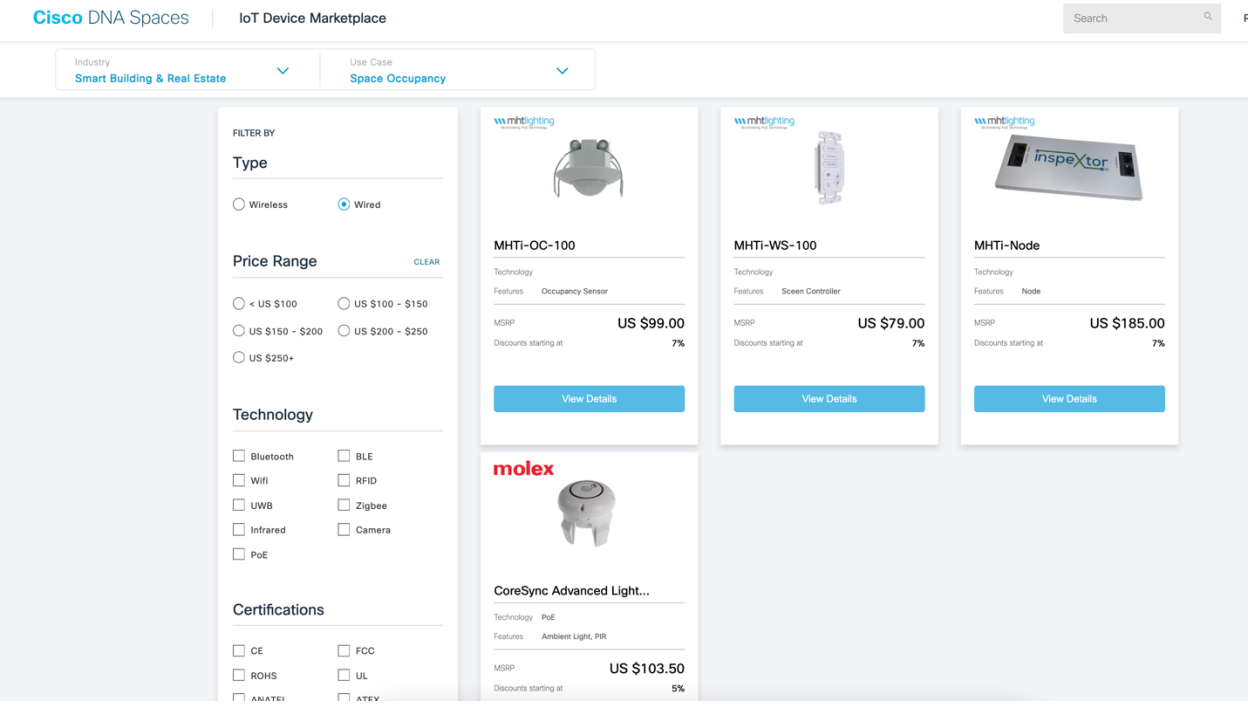
Customers can customize their profiling policies based on the endpoint attributes. Cisco ISE will push the Authorization policy.

8.0 Indoor IoT Services for Wired Endpoints with DNA Spaces

8.1 DNA Spaces

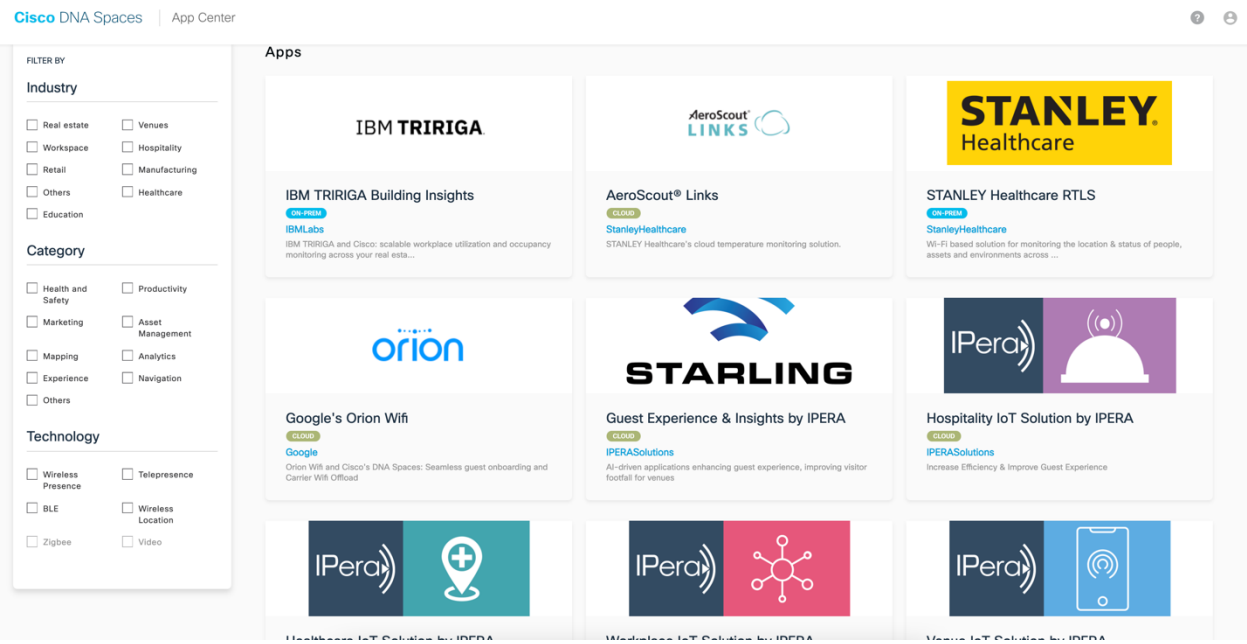
Cisco DNA Spaces is a SaaS-based cloud platform which provides location-based analytics to customers. Cisco has recently integrated Cisco DNA Spaces with the Catalyst 9300/9400 switches. The IoT Gateway is installed as part of this solution on the Catalyst 9300/9400 UPOE/UPOE+ switches. This IoT Gateway helps with relaying the sensor data and telemetry to the DNA Spaces Dashboard.

IoT Marketplace Dashboard on the Cisco DNA Spaces helps customer to find the supported wired or wireless endpoints that meet their use case.



Shown above is Cisco DNA Spaces IoT Device Marketplace. Customers have the flexibility of choosing an industry and use case to populate the supported IoT endpoints that solve that specific need.

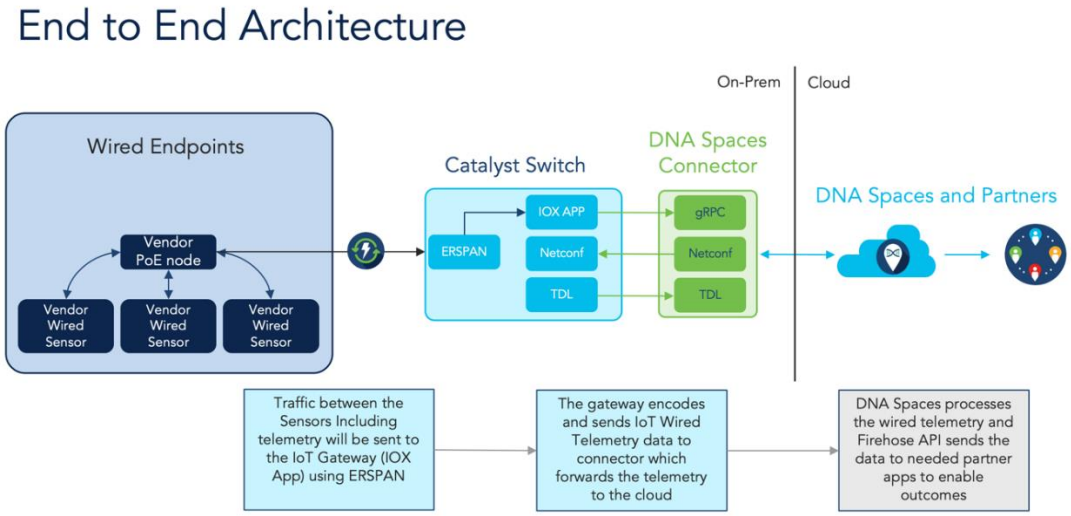
Cisco DNA Spaces has a wide variety of partner applications that a customer can integrate the solution with, to deliver the outcomes based on the use case. The Application store is a third-party application integration system that the customer can use. Once the application is activated, the information will go to the third-party vendor.



Shown above is DNA Spaces Partner App Eco System. Customers have the flexibility of viewing all partner applications based on Industry, Category and Technology. Supported partner applications will be displayed and customers can activate the partner application from the DNA Spaces Partner Application page.

8.2 Indoor IoT Services for Wired Devices – Architecture

Below is an end-to-end architecture of the Indoor IoT services for Wired devices as demonstrated by Cisco. The solution leverages the Application Hosting Framework available on the Catalyst 9300/9400 Series switches to install the IoT Gateway.

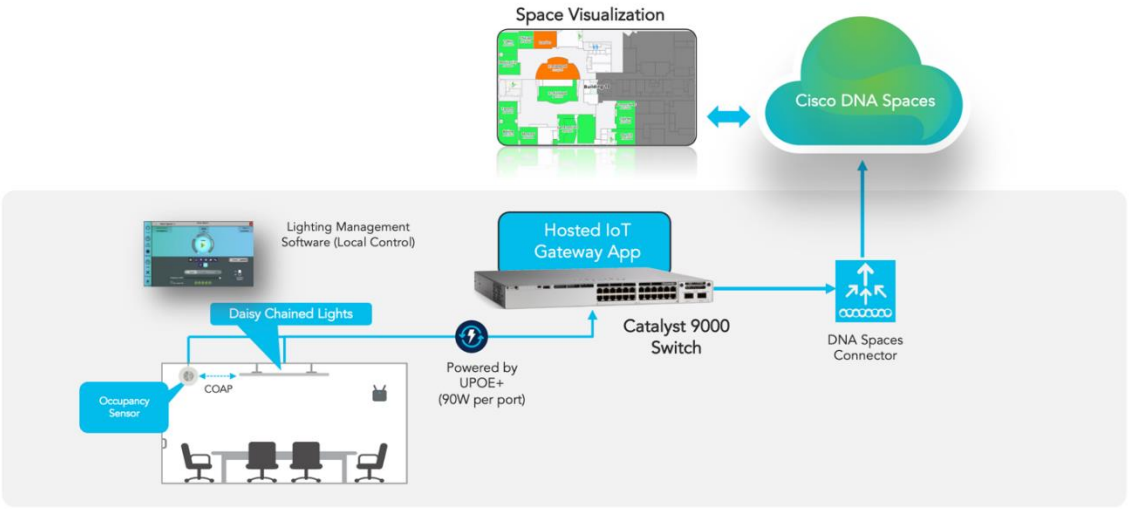


Note: The solution is supported only on Catalyst 9300, 9300L and 9400 UPOE & UPOE+ capable switches with DNA-Advantage or DNA-Premier license.

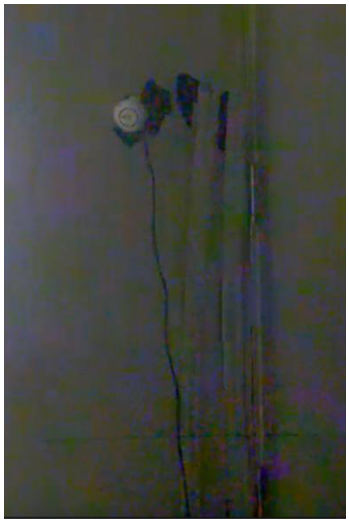
The traffic from the IoT endpoints is redirected to the IoT Gateway application that is hosted as a docker container on the Catalyst 9300/9400 switch. IoT Gateway sends this COAP traffic via gRPC to the DNA Spaces Connector that resides on-prem. In turn, the Spaces Connector sends this data to the DNA Spaces cloud where additional processing is done to unify and feed data into a Firehose API. Here the partners can request the data and work with customers to demonstrate various use cases.

8.3 Test Topology

Cisco demonstrated the end-to-end solution for room occupancy workflow. Daisy chained lights along with an Occupancy sensor were connected to a single 90W on the Catalyst 9000 switch. Below is the topology that was used to validate the end-to-end flow.

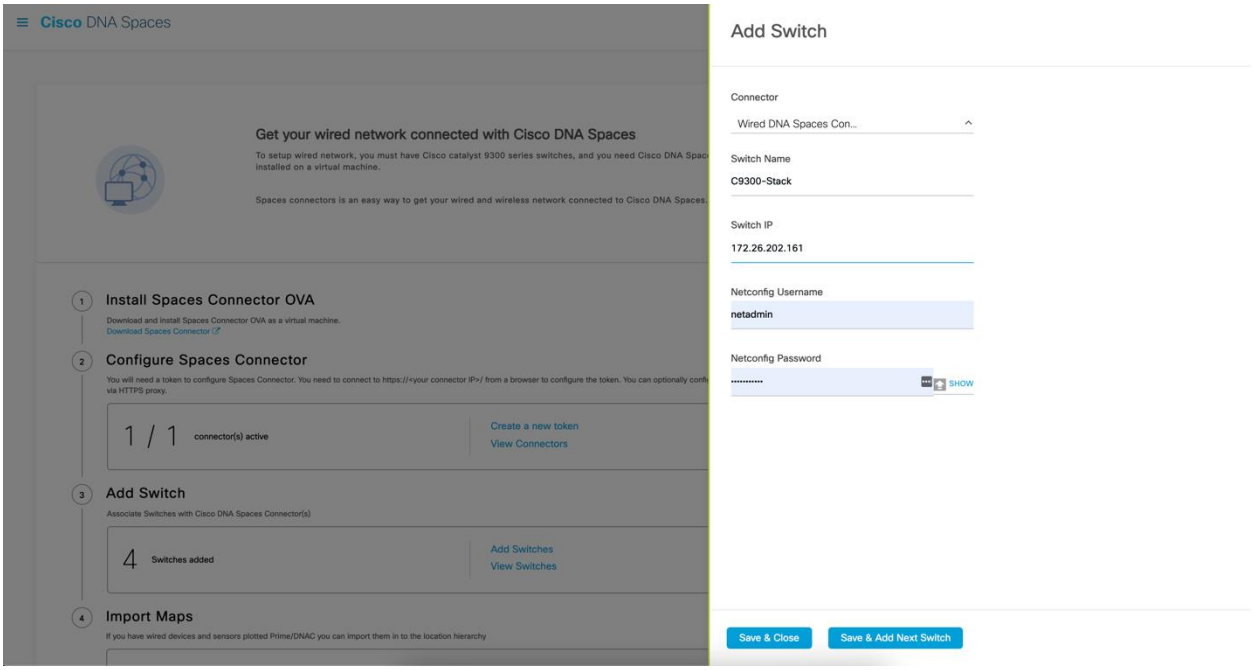


Daisy chained lights with an Occupancy Sensor.



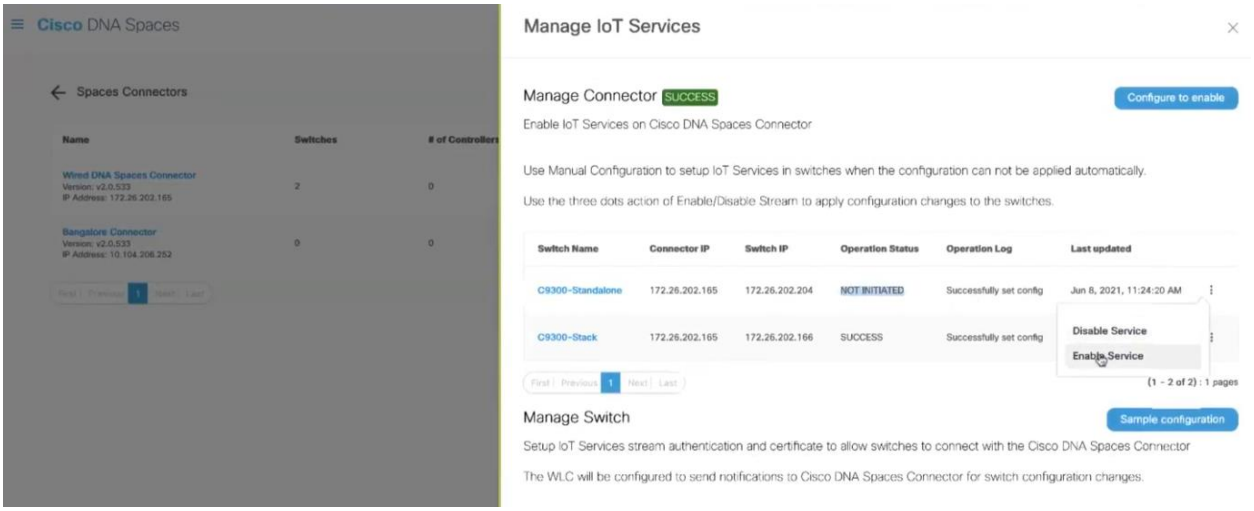
For the partner application, Mazemap was demonstrated where the occupancy of the conference room was dynamically changed based on the occupancy room.

8.4 Test Results

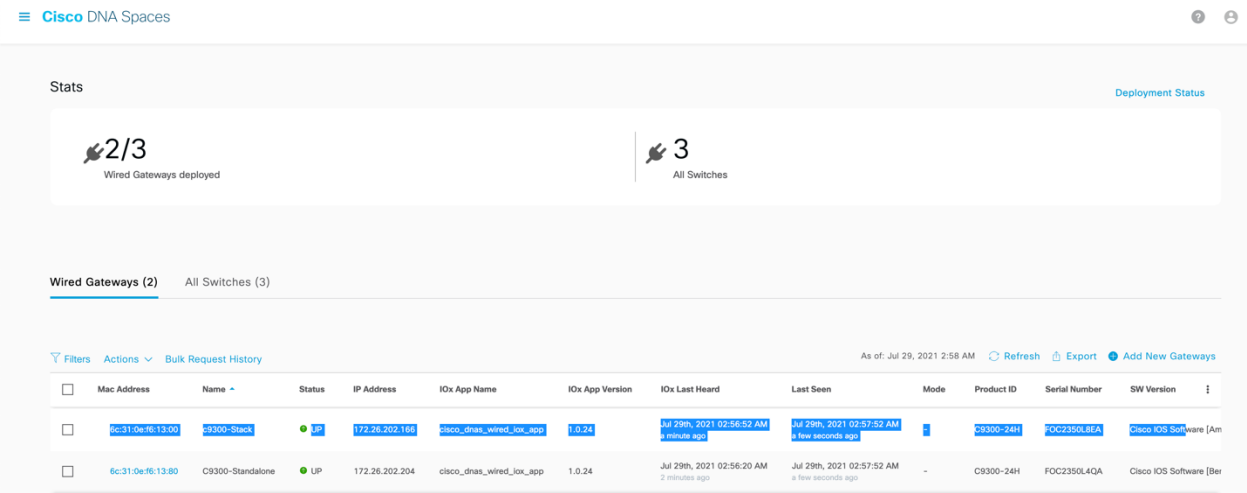


First the switch is added to the DNA Spaces Dashboard.

We observed how we can add the switch onto the DNA Spaces Dashboard, to enable the gateway, and relay the sensor information that is sitting on-premises on the Catalyst 9300/9400 to the cloud and view the status changes.

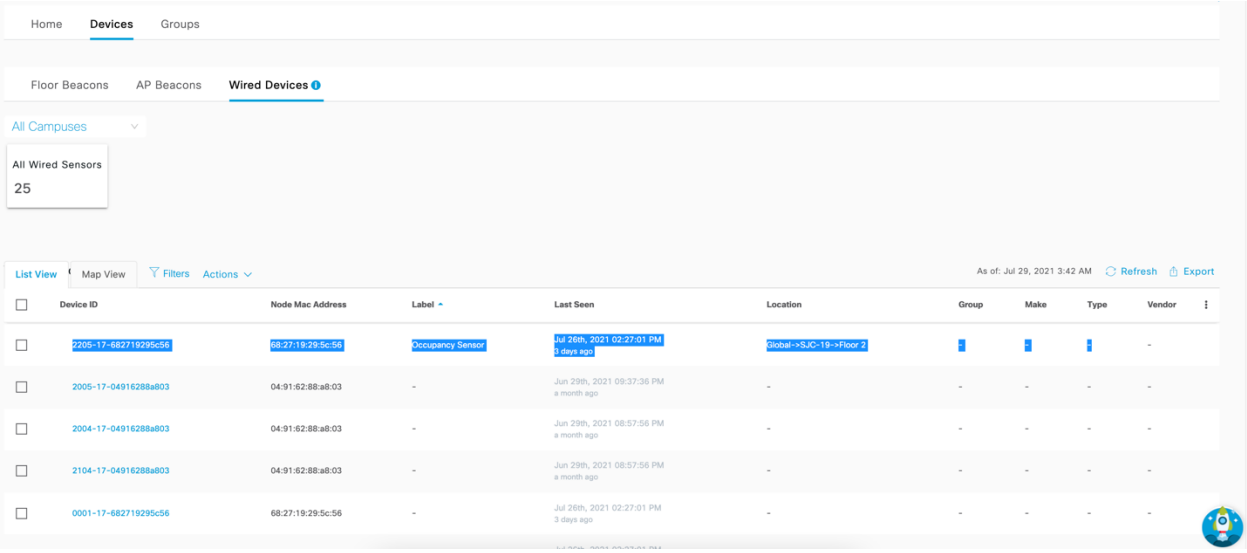


The IoT service is enabled which gets the switch ready to receive information from the IoT sensor to the gateway and the gateway to the DNA Spaces dashboard.



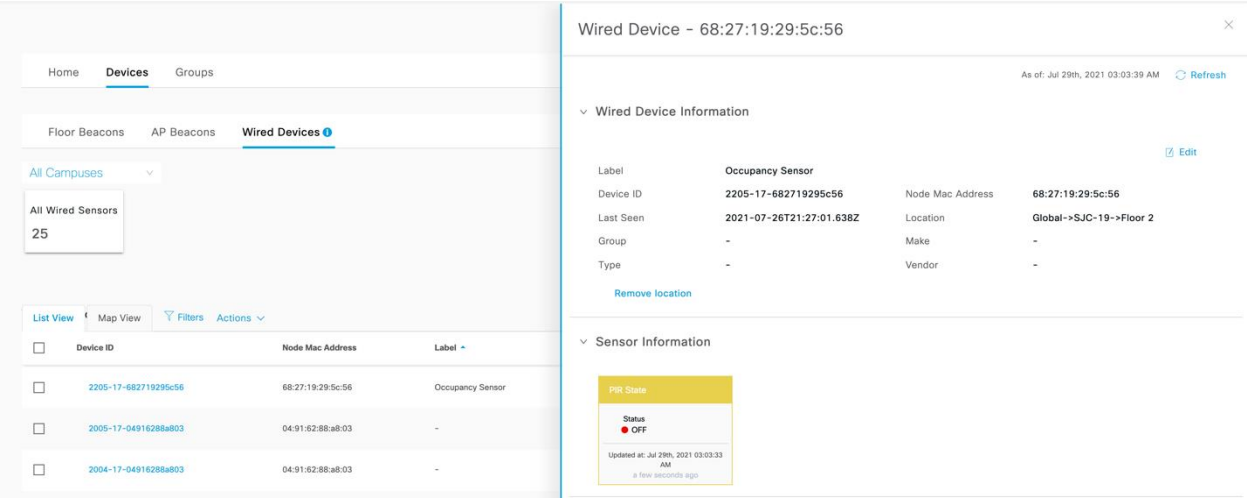
Enabling the IoT Gateway application, by navigating to IoT Gateway, users can deploy the gateways by selecting from the added switches. The IoT gateway will now be installed on the selected switch.

IoT Gateway uses the Cisco Application Framework and has been installed seamlessly with a single click from the DNA spaces dashboard:



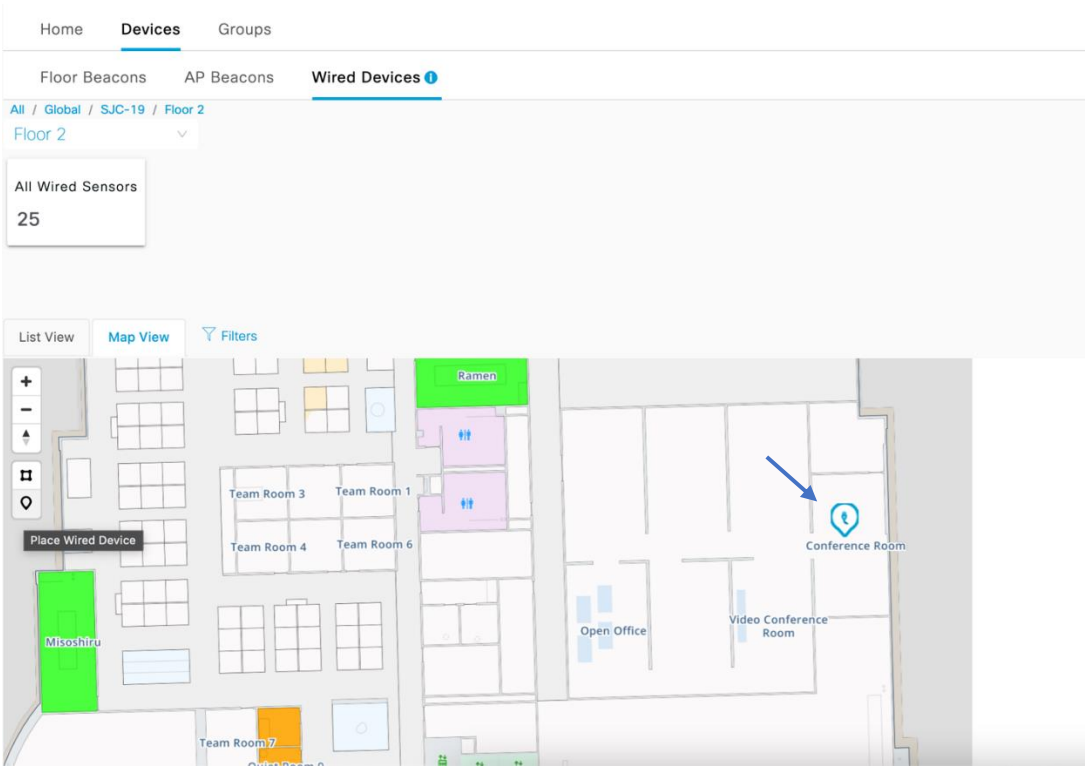
We could see 25 wired sensors auto discovered immediately after the IoT Gateway application installation. The highlighted sensor is the occupancy sensor and is part of the topology that we discussed earlier

A user can further click on each sensor to get more details and the status of the sensor:



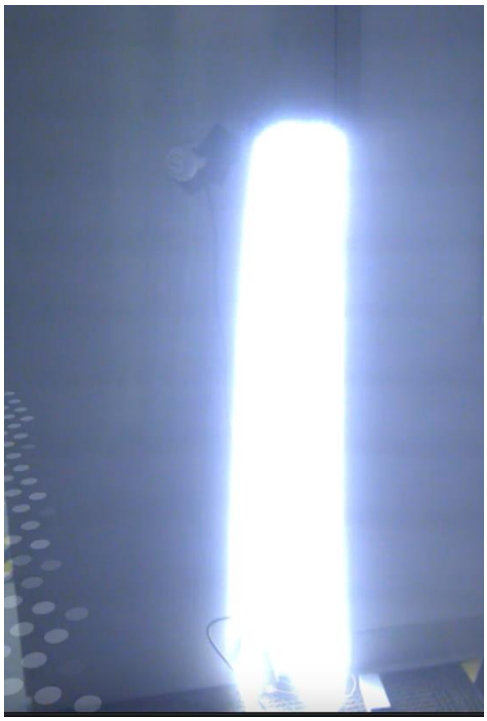
Above, clicking on one sensor, we could see that this is an occupancy sensor, and the current status is off; which means that no presence has been detected (no occupancy in the room).

This sensor can be easily mapped to a conference room on the floor plan by simply clicking the "Place Wired device" icon:



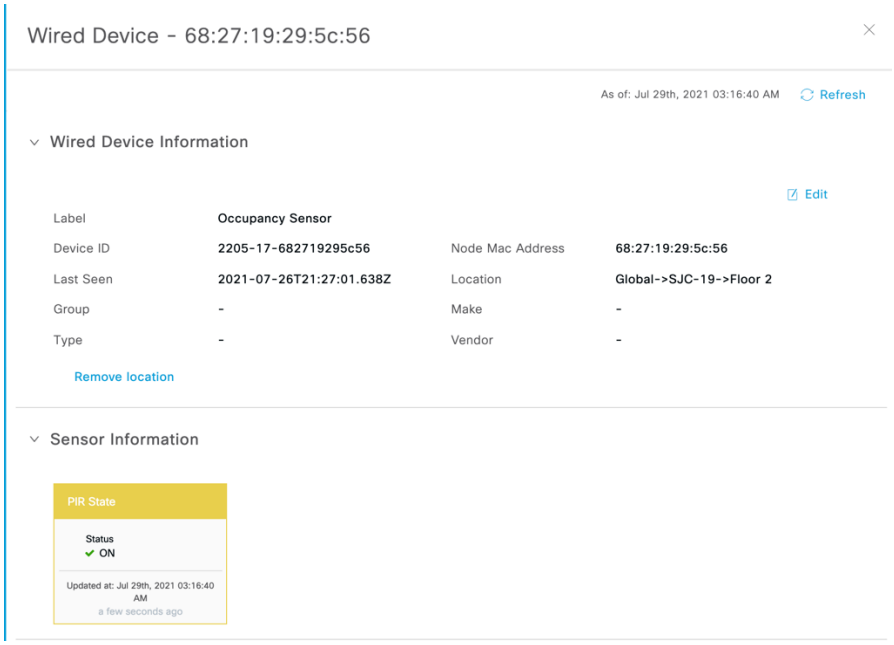
Above, we can see that the Occupancy sensor has been mapped to the conference room.

Movement was simulated in the conference room via a robot that went past the Occupancy sensor. As soon as the sensor detected presence, lights were automatically turned on in the room:



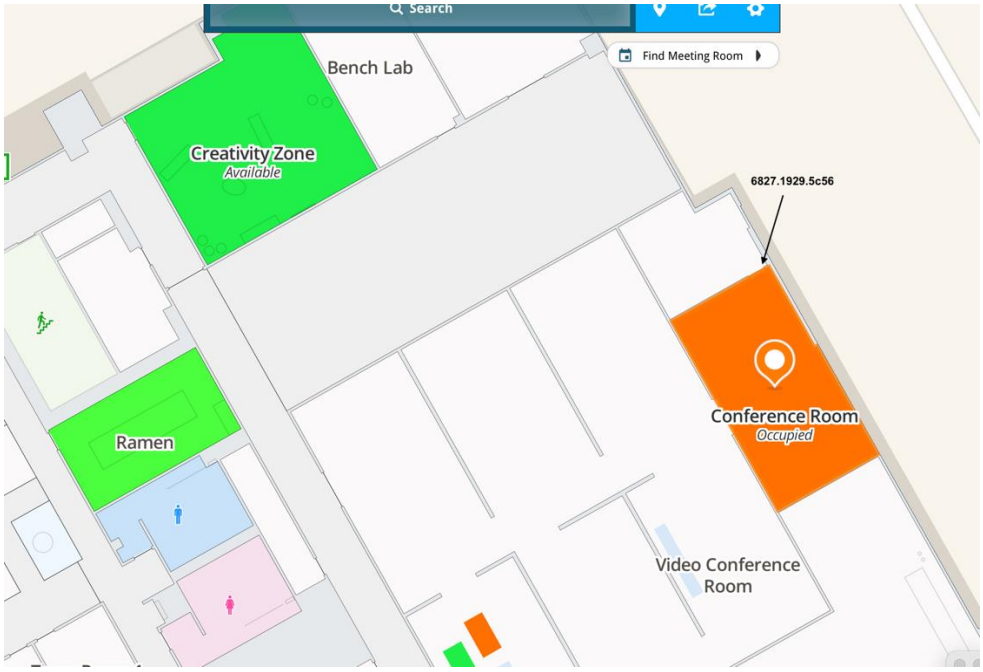
Lights status as soon as presence detected in the conference room.

We noticed the status change of the sensor on the DNA spaces dashboard transition to “ON” state:



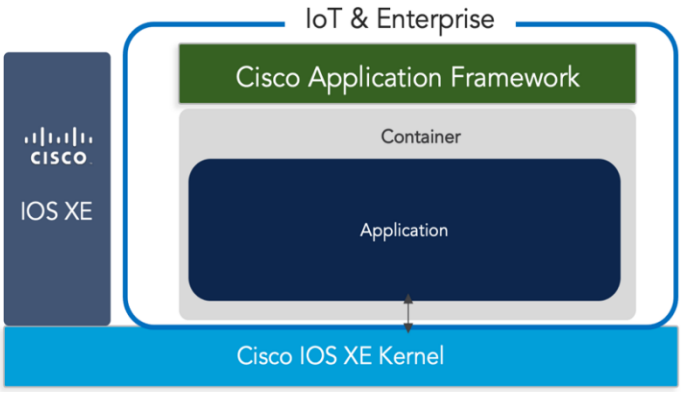
Occupancy sensor status on the DNA spaces dashboard upon detecting Occupancy.

We observed the conference room status on the Mazemap application transition from “Available” to “Occupied”. The Occupancy sensor detects the presence and triggers the lights to turn ON . This trigger has been picked up by the Catalyst 9000 switch and relayed to the IoT Gateway application. This info is sent to the DNA spaces cloud via the on-premises DNA Spaces Connector. Additional processing is done on this event and the information has been relayed to partner application (Mazemap) in a unified format via the Firehose API. Mazemap, the partner application in this scenario, picks up the coordinates of the sensor and transitions the state of the conference room from Available to Occupied. Customers can view this via a URL or an application and do additional integrations to use this data for on-demand conference room booking, get statistics/analysis around real estate usage per building/floor, or other details.



Conference room status on the Mazemap (partner application) shows conference room status change from Available to Occupied.

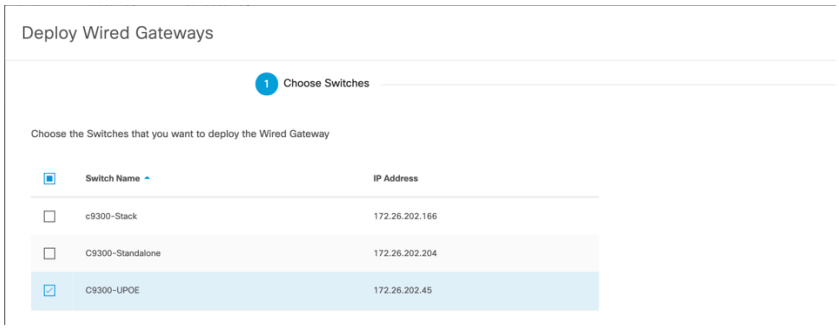
9.0 Application Hosting Capabilities



Enterprise networks are now dealing with massive volumes of data, and there is a critical need to collect and analyze this data to respond faster and deliver insightful context. Traditional approaches of processing in remote servers will no longer work as it can be burden to the network unless some context is known. Edge computing can greatly reduce the data sent to the cloud or a remote server. Powered by an x86 CPU, the application hosting solution on the Cisco Catalyst 9000 series switches provide the required edge intelligence. This gives administrators a platform for leveraging their own tools and utilities, such as a security agent, IoT sensor, and traffic monitoring agent.

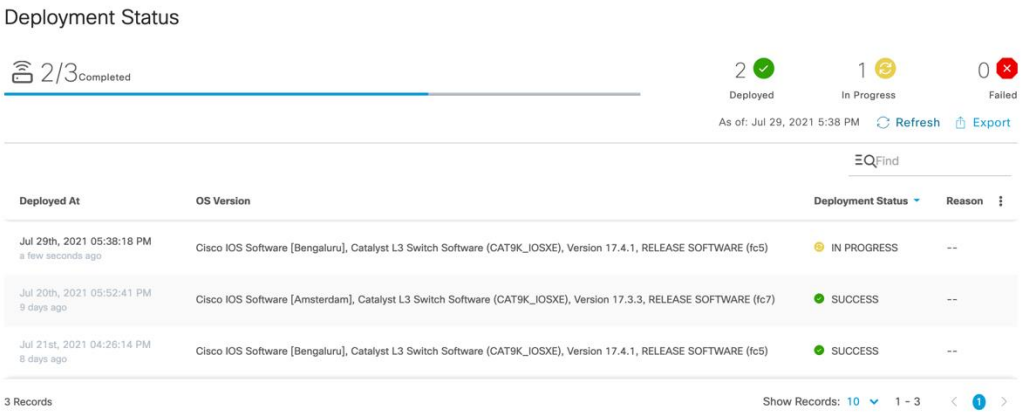
9.1 Application Installation

The applications can be installed on the Catalyst 9000 switches via CLI or DNA Center or Cisco DNA Spaces (IoT Gateway App). Cisco demonstrated hosting of IoT Gateway application on Catalyst 9300 via the Cisco DNA Spaces dashboard.



Note: Only IoT Gateway application can be installed/managed via Cisco DNA Spaces. All other applications can be installed/managed from Cisco DNA Center.

In the "Deploy Wired Gateway" section, DNA Spaces Dashboard lists available switches where you can host the IoT Gateway application.

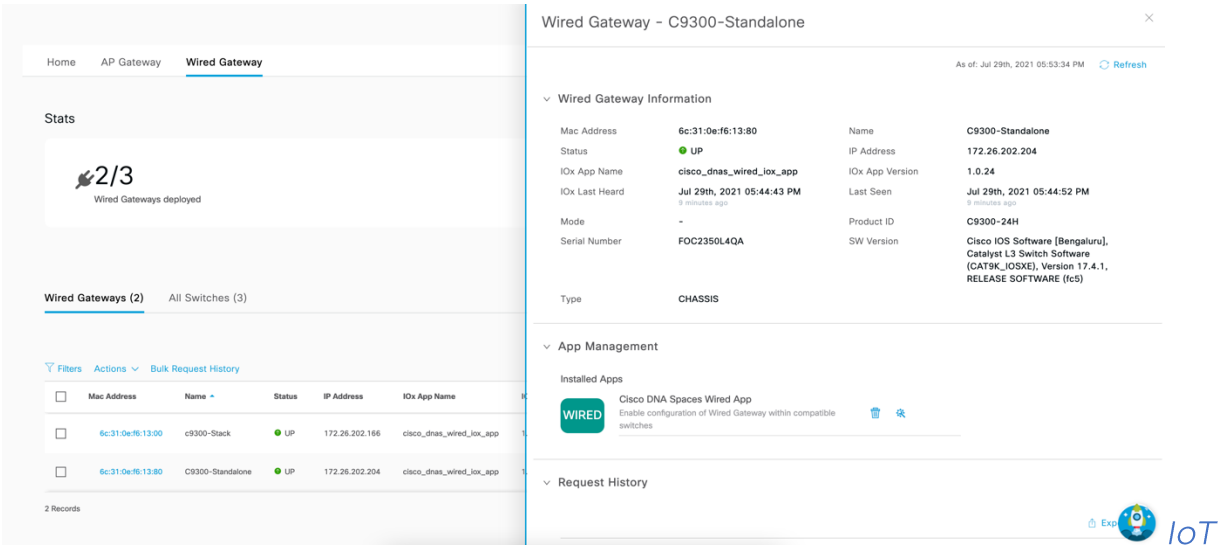


Above image shows two switches. The user can select any switch from the available list and click Deploy.

Below we see a wired IoT Gateway deployment in progress. Once the application has been deployed, traffic is automatically redirected to the application. The application status can be checked directly via the Cisco DNA Spaces dashboard or via CLI:

```
C93-Standalone#sh app-hosting detail
App id                 : cisco_dnas_wired_iox_app
Owner                  : iox
State                  : RUNNING
Application
  Type                 : docker
  Name                 : Cisco DNA Spaces Wired IOx Application
  Version              : 1.0.24
  Description          : The Cisco DNA Spaces Wired Manager app.
  Path                 :
  URL Path             :
Activated profile name : custom

Resource reservation
  Memory               : 1024 MB
  Disk                 : 10 MB
  CPU                  : 3700 units
  CPU-percent          : 50 %
  VCPU                 : 1
```

Gateway application status via CLI commands.



Gateway application status via DNA Spaces dashboard.

Lifecycle management of the application is done from the DNA Spaces (Day 0 to Day N related functionalities).

Cisco Application Hosting Framework can be used to install any third-party application in docker format. This gives customers access to Distributed Edge Computing resources, to deploy an application based on the use case.

Key Advantages:

- AI Endpoint Analytics leverages capabilities of Catalyst 9000 to learn multiple attributes about the endpoints and profile them automatically.
- Users can view all the endpoints in the Endpoint Inventory and can manually add custom rules in addition to system and auto generated profiles.
- Visual aids give customers insight on active endpoints, allowing them to further customize profiling policies.
- SaaS-based cloud platform, DNA Spaces, provides seamless location-based analytics.
- Customers can purchase IoT endpoints from the IoT Device Marketplace of DNA Spaces dashboard based on the use case.
- DNA Spaces has a huge partner eco-system which can consume the data from firehose API to deliver new business outcomes.
- Application Hosting Infrastructure provides Distributed Edge Computing resources to install and manage dockerized applications.

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